POWER PLANT ENGINEERING

Established Over 34 Years

VOL. XXXIV CHICAGO, OCTOBER 15, 1930 No. 20

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 171 Madison Avenue

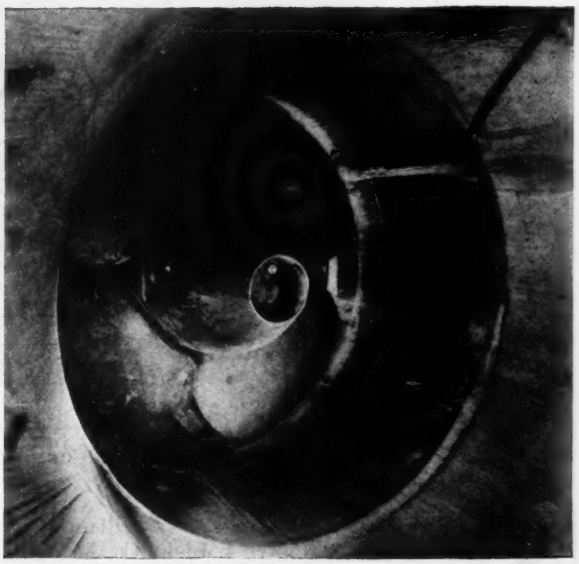
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1930, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this issue 23,450



Eye, Eye, Sir!

AND THIS IS THE EYE. It is shown, magnified some 40 diameters, after being removed from a salmon taken from the Merced River in California below the recently-remodeled hydroelectric plant of the San Joaquin Light & Power Co. The fisherman, on landing the salmon, looked him squarely in the eye to make certain that he recognized his master and noticed in the left eye an expression different from the usual supercilious stare of this species.

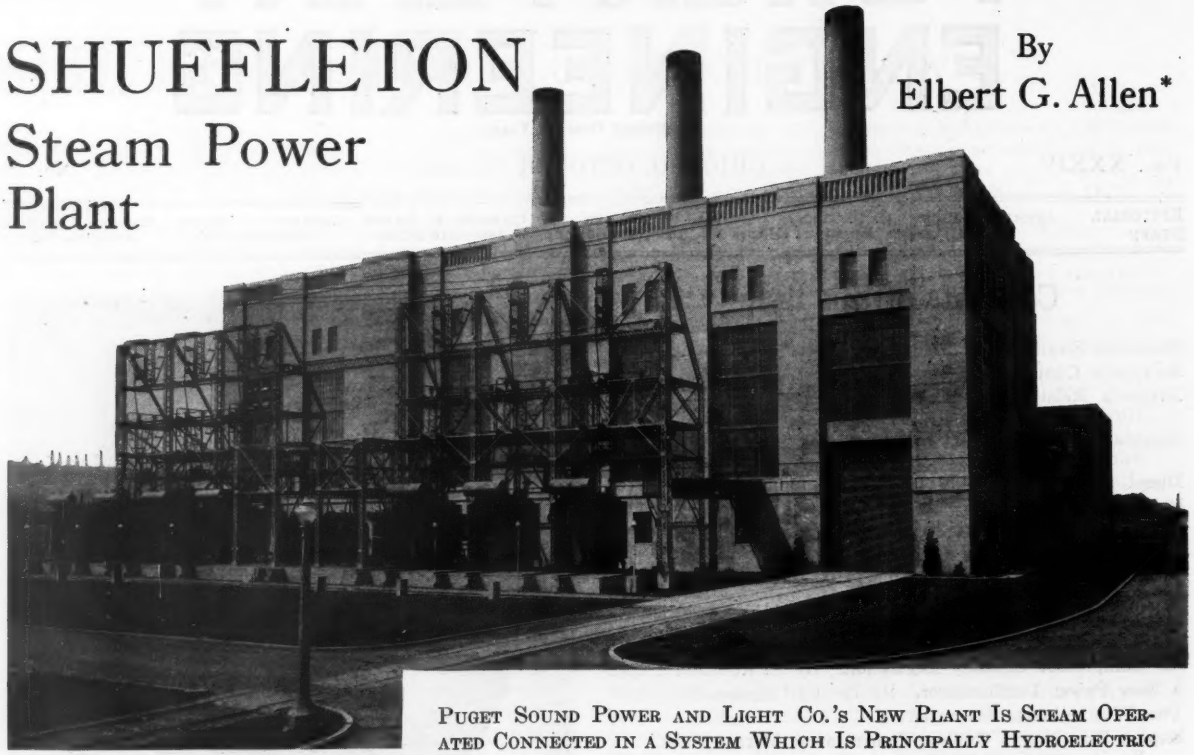
On examination under the microscope, there was found firmly imprinted on the retina of the eye the image of what appears to be a hydraulic turbine. Now, by a curious coincidence, there *is* a new Kaplan automatic adjustable blade propeller turbine at the Merced Falls plant. Also it is a notable fact that a fish ladder was built at the plant but that no salmon has ever made use of it.

The conclusion is obvious. This salmon swam up the tailrace and, instead of going up the ladder as he should have done, got into the draft tube by mistake. He was a young and unsophisticated fish and what he saw on looking up that draft tube horrified him so that it was indelibly printed on his eye. Undoubtedly his horror was so keen that he immediately warned all his fellow salmon and that is the reason none of them has ever attempted to use the fish ladder so humanely provided for them.

If scientific proof of this conclusion is needed in addition to the above photograph, turn to page 1180 where you will find a picture of the fish ladder itself.

SHUFFLETON Steam Power Plant

By Elbert G. Allen*



PUGET SOUND POWER AND LIGHT CO.'S NEW PLANT IS STEAM OPERATED CONNECTED IN A SYSTEM WHICH IS PRINCIPALLY HYDROELECTRIC

SHUFFLETON STEAM POWER Plant of the Puget Sound Power & Light Co. is located in Renton, Washington, on Lake Washington, about 10 mi. from Seattle. It is named in honor of Samuel L. Shuffleton, vice-president of Stone & Webster Engineering Corp., who has been identified with much of the power development on the Pacific Coast during the past 30 yr. His hydroelectric activities have included not only many of the plants of the Puget Sound Power & Light Co., but also many other hydroelectric power plants in Washington and California. He has also constructed many large steam power plants, including the C. F. Huntley Station of the Buffalo General Electric Co. and the Long Beach Steam Plants Nos. 2 and 3 of the Southern California Edison Co., Limited.

Most of the generating system of the Puget Sound Power & Light Co. is hydroelectric, including 153,000 kw. of water power plants. There are several reserve steam plants, chief of which is the one at Georgetown, a suburb of Seattle, where a plant was built in 1907 and now contains 23,000 kw. of steam turbine-generators. These turbines are now relatively inefficient and of obsolete type but the station is suitable for reserve in case of failure of other plants or in case of lack of water for the hydro plants due to extreme drouth.

The location of the Shuffleton Steam Power Plant is peculiarly advantageous. Lake Washington is a fresh water lake 20 mi. long and about 3 mi. wide, forming the easterly boundary of the City of Seattle. It is a deep lake and is connected with Puget Sound by a Government canal constructed to accommodate ocean-going craft. The water of the lake is of excellent quality being supplied by mountain streams. It is used for circulating water for the main condenser, make-up supply to the evaporator equipment and general services in the plant. At the south end of the lake a level tract of land was secured, comprising about 50 acres with 7280 ft. of water front. This tract is adjacent to two railroads, one a transcontinental connection and the other a local road connecting with a coal mining district a few miles distant.

Initially, the plant contains two 35,000-kw. turbine-generators with definite provision for expansion up to at least 310,000 kw. capacity. The fuel will be oil for the present but change can be made to powdered coal whenever desirable. Alternative provision is also made for the changes necessary for burning hogged fuel (wood waste) under the three initial boilers.

Main Units

The main units are of General Electric manufacture rated at 35,000 kw. at 80 per cent power factor, or, 43,750 kv-a. and 1800 r.p.m. The first unit has 17 stages and the second, 15. Both are designed for steam at 400 lb. gage pressure and 725 deg. F. with exhaust pressures from ½ in. to 1½ in. absolute.

Generator windings are cooled by a closed air system with tubular surface type air coolers with water from the condenser circulating water system. A carbon dioxide fire extinguishing system is also provided.

Building

For the first two units, the main building is 172 ft. wide by 214 ft. long. Subsequent additions will be 153 ft. length for each two generating units and three boilers. The building is divided into three bays. The bay next the water front contains the boilers, the one on the other side of the building, the turbine generators,

*Report Manager, Stone & Webster Engineering Corp.

and the middle bay, the auxiliary equipment. The floor at ground level is the condenser and boiler room basement floor. The turbines are elevated 22 ft. and the boiler firing gallery 12½ ft. above this ground level floor. There is a basement level below the condenser floor on which are located condenser auxiliaries and various station service equipment. The auxiliary bay includes four floors in addition to the distilled water tanks below the ground level floor.

Several notable features were incorporated in the design of the main building. The middle or auxiliary bay was considered a central tower to which was framed the boiler room and the turbine room steel. The upper room of this bay which extends above the remainder of the main building roof has adequate natural light and ventilation and houses the forced and induced draft

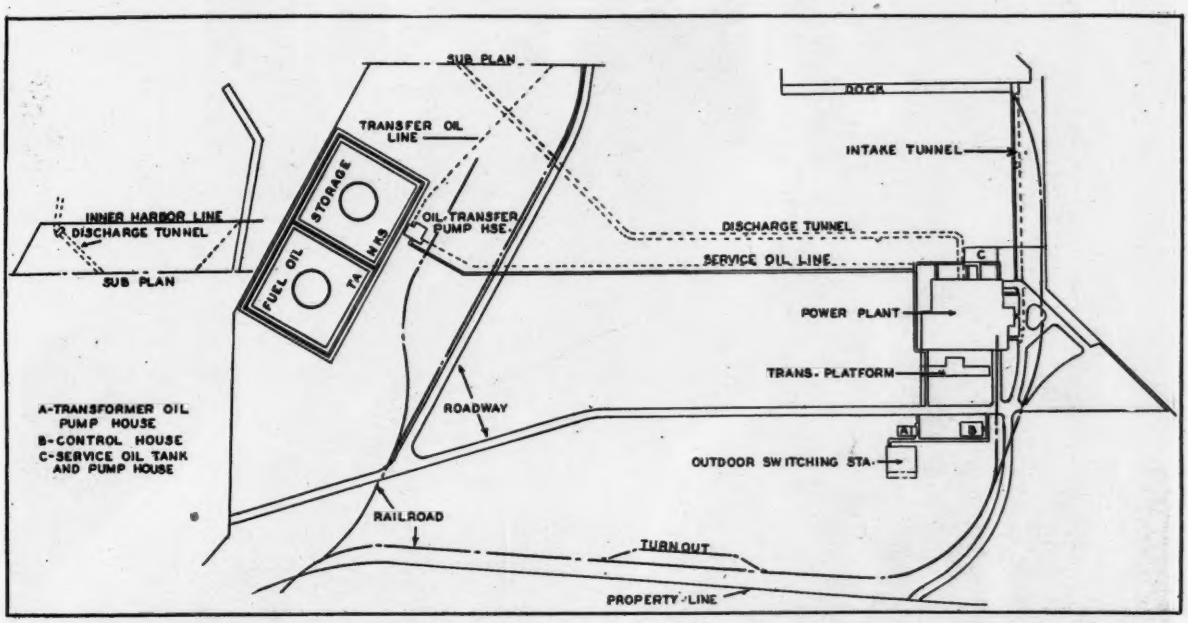


FIG. 1. SHUFFLETON PLANT IS ON FRESH WATER LAKE FRONT ACCESSIBLE TO OCEAN-GOING CRAFT

equipment, while the three concrete stacks are supported on the roof directly above the fan room.

This design not only provided ample light and ventilation for the space above the boilers, but also permitted the boiler supporting steel to be entirely independent of the boiler room building steel. This feature facilitated the design and construction of the main building frame and permitted complete erection of the entire building steel in advance of the fabrication of the boiler support framing.

Hollow walls were provided on both the turbine room and the boiler room sides of the auxiliary bay and these with large chases in the columns and pilasters, facilitated the installation and maintenance of electrical conduit and ventilation ducts. The chases are covered with steel plates, thereby combining the appearance of concealed conduit work with the flexibility of an exposed conduit installation.

The main turbine room has three floor levels, consisting of the turbine support platform, the condenser or ground floor and the condenser pit floor. The condenser pit floor is continuous between units and is about 5 ft. below the normal lake water level, thus permitting the operation of the circulating water and other lake water service pumps without the use of external priming. On this floor are also located the condensate pumps, the distilled water pumps, the fire pump, the condenser wash pump and the electrical control equipment for their driving motors. The large open condenser pit permits the handling of all of the pumps on this level by means of the station crane, except the condensate pumps which are located directly below the main condenser.

Ten feet above the condenser pit is the condenser floor at the same level as the ground floors of the auxiliary bay and the boiler room. On this floor of the auxiliary bay are located the boiler feed pumps and the evaporator with its pumps.

The turbine support platform is a gallery surrounding the turbine and carries the turbine gage boards. It is connected by bridges with the second floor of the auxiliary bay which carries the exciters, evaporator feedwater heaters and emergency auxiliary generator.

In addition to the main building, there are four small auxiliary buildings. The one on the boiler room side of the main building contains fuel oil service tanks and pumps. The operating switchboard is in a two-story building separated by approximately 170 ft. from the main building on the turbine room side. On this side there is also a small building containing transformer oil pumps. The fourth auxiliary building is a small structure near the oil tanks at the farther end of the lot and contains the oil transfer pumps.

Boilers

Stirling type boilers of about 24,800 sq. ft. of heating surface are installed. In the ultimate plan, three boilers are provided for each two 35,000-kw. turbine-generators. Each boiler is equipped with a single loop, single pass convection type superheater and each boiler unit can generate about 330,000 lb. of steam per hour at 450 lb. pressure and 730 deg. F.

FIG. 2. TWO MAIN UNITS AS SEEN FROM NORTH END OF GENERATOR ROOM

Each boiler is equipped with two induced draft and two forced draft fans. The two fans of each kind are mounted on a single shaft which is driven by either of two motors which are of different speeds. By means of automatic combustion control equipment or by push button control, the fan load may be shifted from one motor to the other according to the load conditions. The fans have movable vanes arranged radially on double inlets. These vanes are operated either automatically through combustion control equipment or by remote hand control. Both forced and induced draft fans are located in the upper story of the auxiliary bay between the turbine and boiler rooms.

Each boiler is equipped with an air preheater designed to heat the entering air about 340 deg. F. when the boilers are operated with oil fuel. The furnace walls are water-cooled and comprise about 8 per cent of the boiler heating surface.

Fuel oil supply is received from ocean-going barges which discharge into two 30,000-bbl. storage tanks located at the end of the property most remote from the power station. From these storage tanks, the oil is pumped to two 1000-bbl. service tanks located in the fuel oil service pump house adjacent to the boiler room. The pumps for this service are located in a small building adjacent to the oil storage tanks.

From the service tanks, the oil is heated and pumped directly to the burners. These burners are of a mechanically atomizing type and there are 16 per boiler. Initially the regulation of these burners is by hand but later automatic combustion control may be installed.

Condensers

Surface type condensers are employed. The one for Unit 1 has 40,000 sq. ft. of condensing surface and is designed for 390,000 lb. of steam and an absolute pressure of 0.94 in. Hg. For Unit No. 2, the condenser has 28,000 sq. ft. and is designed for the same amount of steam but an absolute pressure of 1.14 in. Hg. Each condenser has two circulating water pumps, those for the smaller condenser being 24,000 g.p.m. each and for the larger condenser 36,000 g.p.m. each. The discharge circulating water is returned to the lake at a considerable distance from the point of intake.

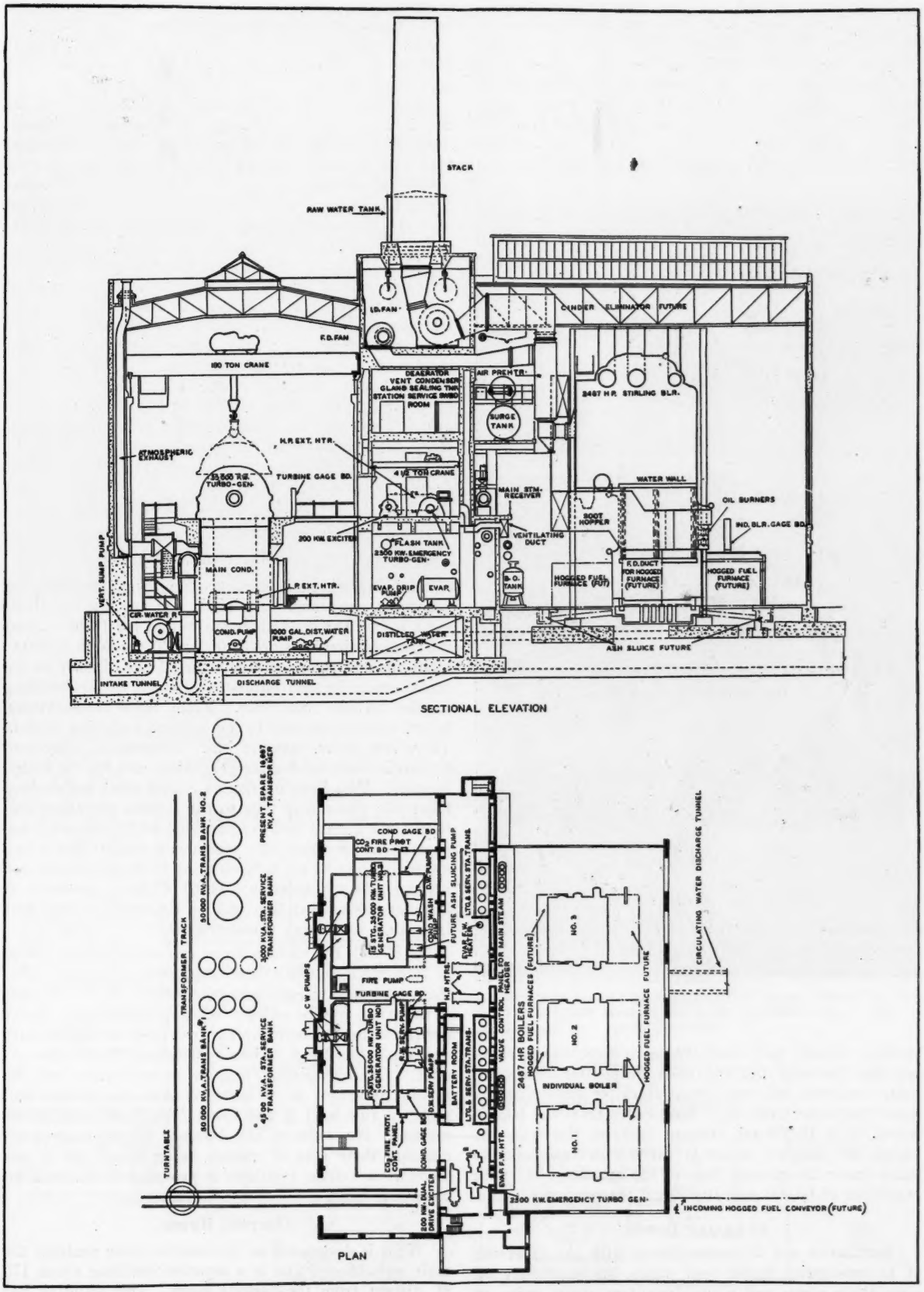


FIG. 3. VERTICAL CROSS SECTION AND PLAN OF SHUFFLETON STATION

Feedwater is heated to a final temperature of about 350 deg. F. by steam bled from the main turbines at three stages. For the 17-stage turbine, these heaters include a low-pressure extraction heater supplied from the fourteenth stage, a deaerating type extraction heater with surge tank supplied from the eleventh stage, and a high-pressure extraction heater supplied from the seventh stage. The fifteen-stage unit has similar heaters supplied with extraction steam bled from the

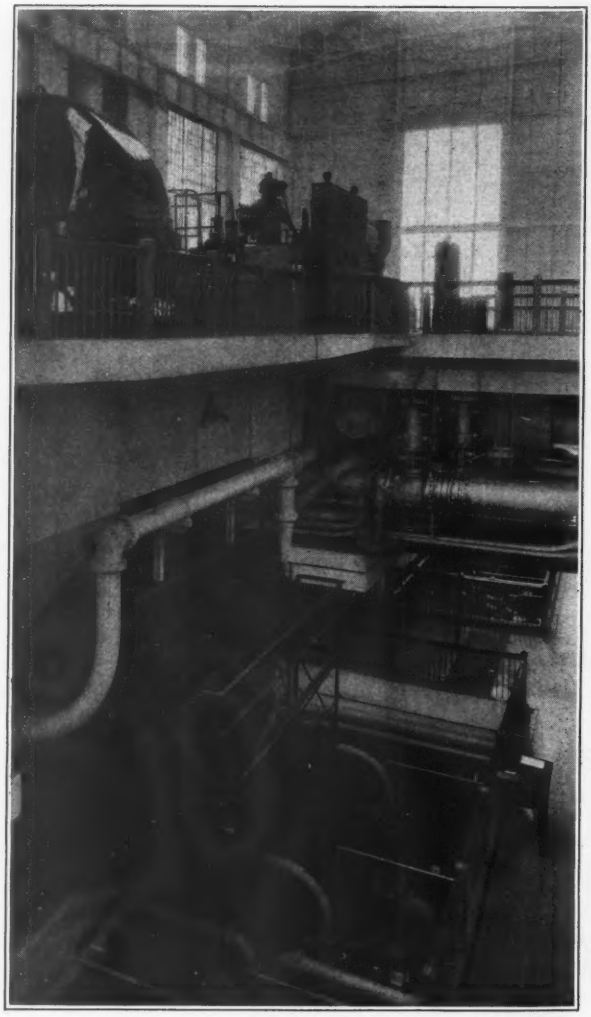


FIG. 4. VIEW FROM MAIN FLOOR SHOWING CONDENSER NO. 1 AND ITS RELATION TO OTHER EQUIPMENT

twelfth, eighth, and third stages, respectively. There are also for each unit an open evaporator feedwater heater and two coil type evaporators for supplying the boiler feedwater make-up. Raw water from the lake is stored in a 12,000-gal. storage tank on the roof. A supply of distilled water is carried in two concrete tanks under the ground floor of the auxiliary bay with capacities of 60,000 and 70,000 gal., respectively.

Auxiliary Power

Auxiliaries are all motor-driven with the exception of an emergency boiler feed pump, an emergency oil circulating pump and a supplementary steam drive on the emergency motor-driven exciter. No steam is used normally other than for the main units except for oil heating and for the condenser air jets.

All motors of 50 hp. and over are 2200 v. except those on the crane. Motors under 50 hp. and the crane motors are 440 v.

Auxiliary power is supplied by a unit system, all auxiliaries for each unit being on a separate bus. Transformers connected to the generator leads supply the 2300-v. station service unit bus. This in turn supplies a 460-v. station service unit bus through separate transformers. There is a connection to each station service unit bus from the corresponding station service emergency bus. The 2300-v. emergency bus is supplied by the house turbine. An outside connection of 450 kv-a. is provided from an outside power line and is designed for lighting and auxiliaries for long shutdowns and slow starting up. The 460-v. station service emergency bus is supplied from the 2300-v. station service emergency bus by a 600-kv-a. transformer bank.

The house turbine-generator is rated at 2500 kw. at 80 per cent power factor. The turbine is noncondensing and the unit is brought into service from a cold standstill condition to full speed and full voltage in approximately 20 sec., automatically, in case the system frequency drops to 58½ cycles. Synchronizing and switching to the 2300-v. station emergency bus is performed by hand.

Switching

Main switching is arranged on a unit system, one generator, one transformer bank, and one line constituting a unit. The generators are wound for 13,800 v. and the transmission lines are 55,000 v. There is no 13,800-v. main bus and the generator wiring leads directly to the transformers located outdoors adjacent to the building on the turbine room side. From these transformers, 55-kv. connections lead to the outdoor switching station. There is a 55-kv. transfer bus. Differential relay protection is provided for the generators and for the transformers. Two lines on double circuit steel towers lead from this generating unit to the Renton switching station, 4 mi. distant and are provided with balanced relay protection. A third line, which is a single circuit line approximately 32 mi. long running to Beverly Park, has reverse power protection. Until a third generator is installed, this third line will be connected to the first through a temporary connection.

Each unit has its own direct connected exciter, which in turn has a separate direct connected subexciter. The main exciters are equipped with double throw switches so that they may be self-excited in an emergency. Relay excitation for the main unit is provided through a spare excitation bus by a 200-kw. emergency dual drive exciter. Ordinarily this unit is motor-driven but the turbine governor is so adjusted that the turbine will pick up full load if the speed falls 2 per cent below normal. The exciters are designed for high-speed excitation, their rate of change being about 250 v. per second. A voltage regulator is provided of the modified rheostatic type.

Control House

What is designated as the control house contains the main switchboard and is a separate building about 170 ft. distant from the turbine room. This building has two stories and contains only the remote control switch-

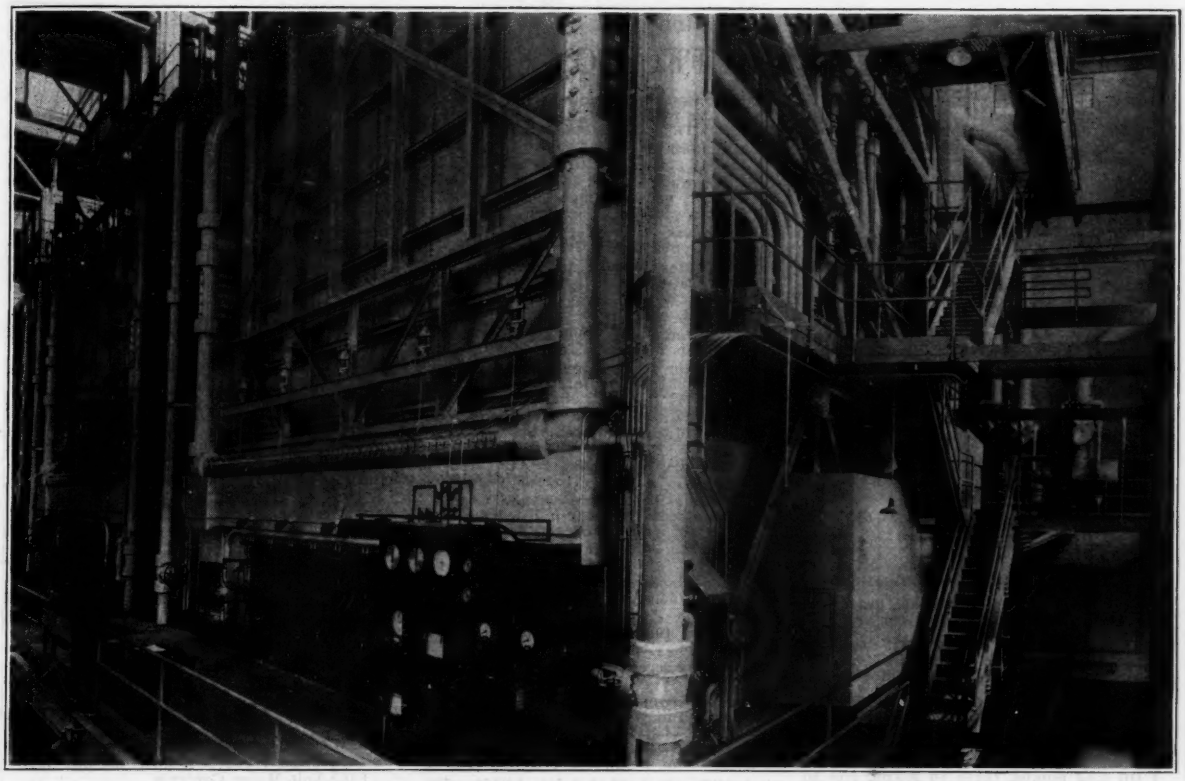


FIG. 5. BOILER NO. 3 AS SEEN FROM THE FIRING FLOOR

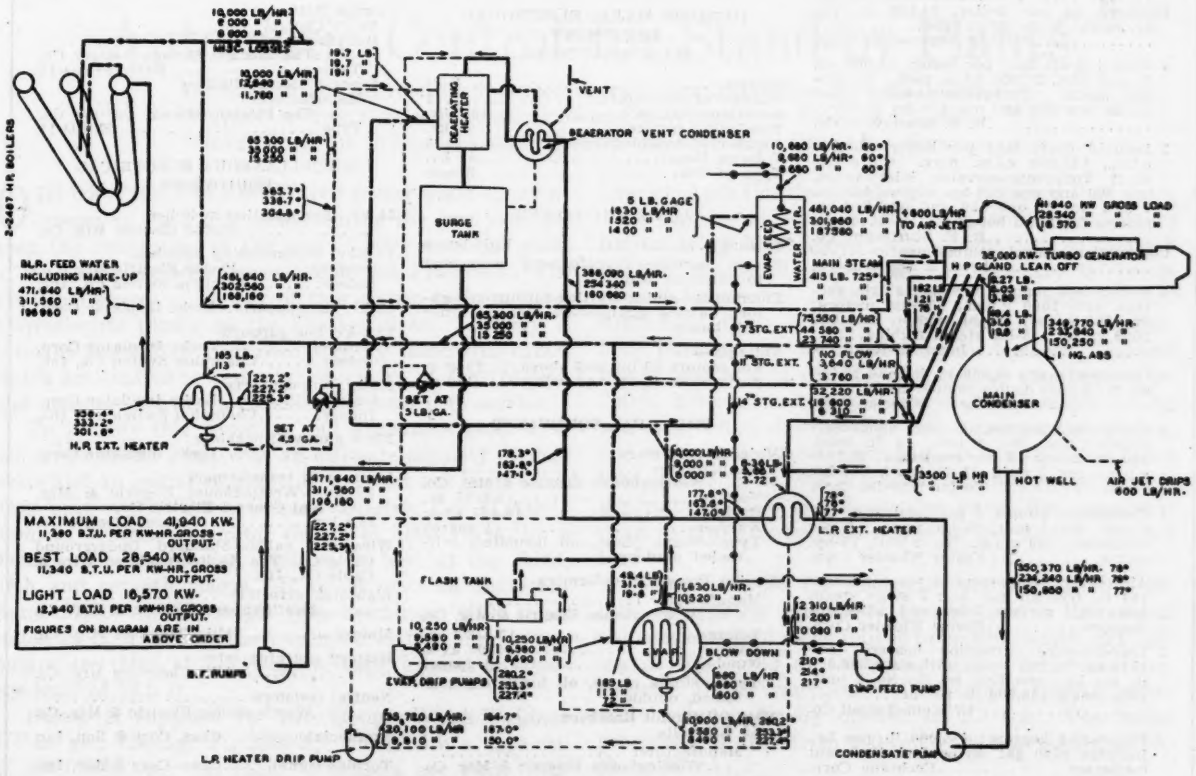


FIG. 6. HEAT BALANCE DIAGRAM CALCULATED FOR THREE DIFFERENT LOADS

EQUIPMENT IN SHUFFLETON STEAM POWER PLANT

DATA ON MAJOR STEAM EQUIPMENT

2 Main turbine generators; 43,750 kv-a., 80 per cent p.f., 13,800-v., 1800 r.p.m., 415 lb., 725 deg. F., steam one 17 stage, one 15 stage.....General Electric Co.

1 House generator; 3125 kv-a., 80 per cent p.f., 2300 v., 3600 r.p.m., 400 lb., 725 deg. F. steam.....General Electric Co.

1 Auxiliary exciter, 200 kw., 250 v., 1170 r.p.m., 400 lb., 725 deg. F. steam, dual drive 300-hp., 2200-v. ind. motor.....General Electric Co.

3 Boilers, two 24,866 sq. ft., one 24,749 sq. ft., Stirling type, 450 lb.....Babcock & Wilcox Puget Sound Machinery Depot

3 Superheaters, two 7710 sq. ft., one 6700 sq. ft., single loop, single pass, convection type, 750 deg. F.....Babcock & Wilcox Superheater Co.

3 Air preheaters, 18,360 sq. ft., Thermix.....Prat-Daniel Corp.

3 Furnace water walls, two 1186 sq. ft., one 1168 sq. ft., Tubing protected on furnace side with refractory faced cast-iron blocks.....Fuller Lehigh Co.

3 Stacks, 8 ft. diameter, 60 ft. high, Reenforced concrete, brick lined, superimposed.....The Rust Co.

2 Fuel oil storage tanks, 30,000 bbl., steel tanks above ground.

2 Tank heaters, 600 g.p.m., 125 lb. gage, heating range 25 to 60 deg. F.....Whitlock Coil Pipe Co.

2 Fuel oil transfer tanks, 600 g.p.m. centrifugal, 75-hp. motor....Byron Jackson

2 Fuel oil service tanks, 1000 bbl., steel tanks below ground.

4 Oil feed pumps, three 80 g.p.m., one 40 g.p.m., Positive displacement screw type; 25 and 15-hp. motors.....Quimby Pump Co., Inc.

3 Oil heaters, 80 g.p.m.....Schutte & Koerting Co.

1 Oil heat exchanger, 80 g.p.m.....Schutte & Koerting Co.

Burners, 16 per boiler, 24,600 lb. per hr. total. Wide range type.....Peabody Engineering Corp.

2 Forced draft fans per boiler, 53,000 cu. ft. per min., 57,700 c.f.m. max. On single shaft. Turbovane-movable inlet vanes, one 300 and one 100-hp. motor.....B. F. Sturtevant Co.

2 Induced draft fans per boiler, 105,000 c.f.m., 135,000 c.f.m. max. On single shaft Turbovane-movable inlet vanes, one 800 and one 250-hp. motors for No. 1 and No. 2; one 450 and one 200-hp. motors for No. 3 boiler.....B. F. Sturtevant Co.

Combustion control, semiautomatic.....Leeds & Northrup Co.

4 Boiler feed pumps, 6 stage, single suction, two 1000 g.p.m., 500-hp. motors; one 500 g.p.m., 300-hp. motor, and one 1000 g.p.m. 428-hp. steam turbine.....Ingersoll-Rand Co.

2 Condensers, one 40,000 sq. ft., one 28,000 sq. ft., 2 pass double compartment.....Foster Wheeler Corp.

4 Circulating pumps, 2 per condenser, 39,500 g.p.m., No. 1 unit, 34 ft. head, 300-hp. motor; 2 per condenser, 36,700-g.p.m., No. 2 unit, 41 ft. head, 350-hp. motor.....Foster Wheeler Corp.

4 Condensate pumps, 2 per condenser, 750 g.p.m., No. 1 unit, 75-hp. motor; 2 per condenser, 800 g.p.m., No. 2 unit, 75-hp. motor.....Foster Wheeler Corp.

2 Air removal equipment, 1 per condenser 154 lb. free air per hr.; 2 stage steam jets with surface inter and aftercondensers.....Foster Wheeler Corp.

2 Low-pressure extraction heaters; one 1930 sq. ft., No. 1 unit, 14th stage 336,000 lb. per hr.; one 1930 sq. ft., No. 2 unit, 12th stage, 366,000 lb. per hr.....Griscom-Russell Co.

2 Deaerating heaters; 475,000 lb. per hr., includes 9500 gal. surge tank and vent condenser.....Cochrane Corp.

2 High-pressure extraction heaters; one 1755 sq. ft., No. 1 unit, 7th stage, 475,000 lb. per hr.; one 1755 sq. ft., No. 2 unit, 3rd stage, 495,000 lb. per hr.....Griscom-Russell Co.

4 Evaporators; two 13,500 lb. per hr., two 14,650 lb. per hr., Single effect.....Griscom-Russell Co.

2 Evaporator feedwater heaters, direct contact, open type...Griscom-Russell Co.

1 Raw water storage tank, 12,000 gal., cylindrical steel.

4 Distilled water storage tanks, 220,000 gal. total, concrete.

2 Raw water pumps, 1000 g.p.m., centrifugal, 50-hp. motors....Ingersoll-Rand Co.

4 Evaporator feed pumps, 53 g.p.m., centrifugal, 7.5-hp. motors.....Ingersoll-Rand Co.

4 Distilled water pumps, 1000 g.p.m., centrifugal, 75-hp. motors.....Ingersoll-Rand Co.

1 Fire pump, 1000 g.p.m., 2 stage, 125-hp. motor.....Ingersoll-Rand Co.

2 Generator air coolers, 90,000 c.f.m., 4 sec. horizontal tubular multipass, 12,000 sq. ft.....General Electric Co.

1 Air compressor, 814 c.f.m., one 125-hp. motor.....Chicago Pneumatic Tool Co.

1 Turbine room crane, 100 ton, 15 t. aux., 4 motor; 55 ft. 4½ in. span.....Niles-Bement-Pond Co.

1 Elevator, 4000 lb., push button control, 100 f.p.m.....Otis Elevator Co.

2 Traveling screens, 8 ft. 3¼ in. by 27 ft.; 10 f.p.m., 3-hp. motor.....Link-Belt Co.

1 Station transformer room vent fan, 10,000 c.f.m., 3-hp. motor.....B. F. Sturtevant Co.

1 Truck switchboard room vent fan, 3,800 c.f.m., 1-hp. motor..B. F. Sturtevant Co.

1 Auxiliary bay exhaust fan, 14,400 c.f.m., 3-hp. motor.....B. F. Sturtevant Co.

1 Auxiliary bay battery room fan, 850 c.f.m., ½-hp. motor.B. F. Sturtevant Co.

1 Control house battery room fan, 320 c.f.m., ¼-hp. motor.B. F. Sturtevant Co.

DATA ON MAJOR ELECTRICAL EQUIPMENT

MAIN SWITCHING

System .....Unit
Number of generators.....2
Generator voltage .....13.8 kv.
Paralleling voltage .....55 kv.
Number of outgoing lines.....3
Voltage, lines.....55 kv.
Type of bus.....Single

AUXILIARY POWER

System .....Unit buses
Source normal—Transformers connected to generator leads.
Emergency—Quick starting turbine-generator; outside distribution circuit; other unit buses.
Voltages—
For motors 50 hp. and above....2300 v.
For motors 40 hp. and below.....440 v.

PRINCIPAL EQUIPMENT

Main Transformers
Manufacturer .....Westinghouse Electric & Mfg. Co.
Voltage .....13.8/55 kv.
Rating .....16,667 kv-a.
Number.....7 (1 spare)
Type—Single phase, oil insulated, self-cooled, outdoor.

Station Power Transformers
Manufacturer .....Westinghouse Electric & Mfg. Co.
Voltage .....13.8/2.3 kv.
Rating .....1500 kv-a.
Number.....5 (1 spare)
Type—Single phase, oil insulated, self-cooled, outdoor.

Main Oil Circuit Breakers
55 Kilovolts
Manufacturer .....Westinghouse Electric & Mfg. Co.
Number 5
Type .....Outdoor
Rating....3—1200 amp., 2—600 amp.
Rupturing capacity....1,500,000 kv-a.

13.8 Kilovolts
Manufacturer .....Westinghouse Electric & Mfg. Co.
Number—1 (generator breaker omitted on Unit No. 2).
Type.....Indoor, cell mounted
Rating .....3000 amp.
Rupturing capacity....1,500,000 kv-a.

Switchboards
Main Control Switchboard
Manufacturer....General Electric Co.
Type—Vertical instrument and relay panels back to back, circular.
Location .....Control House

Excitation Switchboard
Manufacturer....General Electric Co.
Type—Vertical air circuit breaker panels.
Location.....Under turbine platform

Control Battery Switchboard
Manufacturer....General Electric Co.
Type .....Vertical
Location .....Control House

Valve Battery and Lighting Switchboard
Manufacturer....General Electric Co.
Type .....Vertical
Location .....Auxiliary bay

2300-Volt Station Power Switchboard
Manufacturer .....Condit Electrical Mfg. Corp.
Type .....Truck
Location .....Auxiliary bay

460-Volt Station Power Switchboard
Manufacturer .....I-T-E Circuit Breaker Co.
Type .....Steel enclosed, air circuit breaker
Location .....Auxiliary bay

2300-Volt Motor Controls
Manufacturer....General Electric Co.
Type—Dead front vertical panel with panel mounted oil circuit breaker.

440-Volt Motor Controls
Manufacturer.....A. G. Mfg. Co.
Type—Unit—steel enclosed contactor, disconnecting switch and bus.

Storage Batteries
Valve Control
Manufacturer .....The Electric Storage Battery Co.
Type .....Exide FOGO-19
Control Storage Battery
Manufacturer .....The Electric Storage Battery Co.
Type EOGO-17

MISCELLANEOUS ELECTRICAL EQUIPMENT

55-kv. disconnecting switches.....Pacific Electric Mfg. Co.

13.8-kv. disconnecting switches
Outdoor.....Pacific Electric Mfg. Co.
Indoor.....Champion Switch Co., Inc.

55-kv. bus supports..Locke Insulator Corp.

13.8-kv. bus supports
Outdoor.....Locke Insulator Corp.
Indoor.....Champion Switch Co., Inc.

2.3-kv. bus supports
Outdoor.....Locke Insulator Corp.
Indoor.....Champion Switch Co., Inc.

Floor and wall bushings.....Locke Insulator Corp.

Instrument transformers
55 kv.—Westinghouse Electric & Mfg. Co. and General Electric Co.
13.8 kv.....General Electric Co.

Wire and cable—Standard Underground Cable Co., The Kerite Insulated Wire & Cable Co., Inc.

Lightning arrestors .....Westinghouse Electric & Mfg. Co.

Motors .....Allis-Chalmers Mfg. Co.

Battery charging sets.....Allis-Chalmers Mfg. Co.

Neutral resistors .....Westinghouse Electric & Mfg. Co.

Annunciator.....Chas. Cory & Son, Inc.

Turbine signal.....Chas. Cory & Son, Inc.

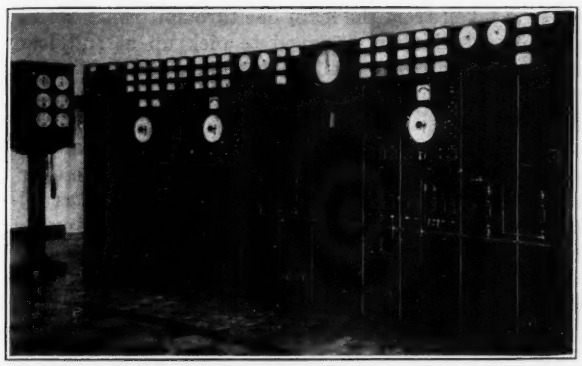


FIG. 7. MAIN SWITCHBOARD LOCATED IN THE CONTROL HOUSE

board and a storage battery for its operation. The arrangement of the panels conforms to the unit system and the control house can be extended to correspond to the addition of units. A lighting system providing illumination approximating daylight has been installed for the switchboard room.

Outdoor Switching Station

The outdoor switching station is of the rigid bus and connection type on a latticed steel structure. The connections are simple since the station is only approximately 4 mi. distant from the main switching station at Renton. Oil circuit breakers are provided for the connection of each main transformer bank to its corresponding line or to a single paralleling bus. Each Renton line is equipped with a lightning arrester and a synchronizing potential transformer and provision made for the future installation of an additional potential transformer and current transformers for metering when desired. The Beverly line is fully equipped for metering at this time.

Auxiliary Switching

Switches and control for the auxiliary station service are located on the third floor of the auxiliary bay. These are in groups corresponding to the main units,

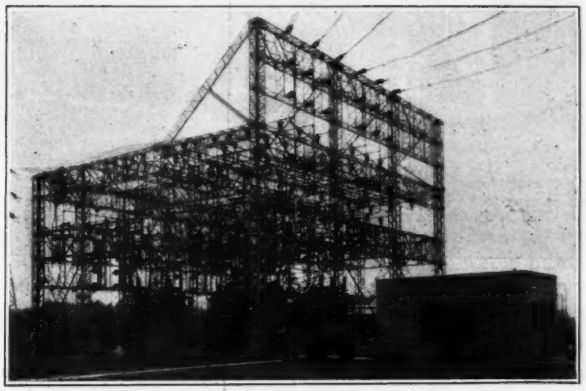


FIG. 8. OUTDOOR SWITCH STRUCTURE FOR 55 KV. AT SHUFFLETON PLANT

each group including a 2300-v. switchboard, a 460-v. switchboard, a control board and a board controlling the lighting for that section of the building. The 2300-v. switch is of the truck type and the 460-v. switchboard is of the steel enclosed air circuit breaker type with removable breaker units. Feeders lead from these boards to control panel groups located conveniently near the various motors.

Automatic Control for Stand-by Plants

Details of the Automatic Control of the New 35,000-Kw. San Francisco Station of the Great Western Power Co. Where the Turbine Throttle Valve Will Be Automatically Opened in One and One-half Seconds

ONE OF THE INTERESTING power plant developments on the Pacific coast during the past year has been the completion of the new 35,000-kw. steam plant of the Great Western Power Co. in San Francisco. The principal source of energy of this system is from three hydroelectric plants on the Feather River. Energy is brought across San Francisco Bay by submarine cables which are limited in capacity, expensive of construction and maintenance and a considerable hazard to service.

To remedy this situation and guarantee good service, a new steam plant with an ultimate capacity of four units and an initial capacity of one unit has been built. This unit, a 35,000-kw. General Electric Co. 11,000-v., 3-phase, 60-cycle generator driven at 1800 r.p.m. by a 9-stage, 450-lb., 725-deg. turbine, is bled at the third, fifth and seventh stages. It is set over an Ingersoll-Rand 27,400-sq. ft., single pass condenser with tubes rolled at both ends. The two motor-driven circulating pumps are rated at 35,000-g.p.m. each, against an average head of 18.5 ft.

Steam is supplied by two Hedges-Walsh-Weidner 450-lb. ga., 725-deg. F., 2225-hp. units with a capacity of 290,000-lb. per hr. each. Furnaces are built with Detrick Arch Co. air-cooled walls so designed that water walls can be added at a later date, while the furnace bottom is set 20 ft. above the basement floor so that ash hoppers can be added in case it is necessary to change to coal burners at a later date. Forced and induced draft fans are provided and the boiler is fired by 29 Peabody burners, nine of which are pilot burners. Natural gas is used as fuel with oil provided as stand-by. Two 250-v. 200-kw. exciters are provided, one motor driven and one turbine driven. The same arrangement, that is, one motor and one turbine drive, is used for the boiler feed pumps, each with a capacity of 1000-g.p.m. against a pressure of 600 lb. Feedwater leaves the evaporator condenser and enters the boiler at 261 deg. F. at full load.

Being designed for emergency stand-by service, the most interesting feature of this station is the special automatic control. The unit is to be kept warm and rolling at full speed at all times, as a synchronous condenser. Under emergency, the turbine throttle valve will be automatically opened in 1.5 sec. The boiler pressure will drop from 400 to 200 lb. and return to 350 lb. in 20 min.

FIG. 1. EXTERIOR VIEW OF THE SAN FRANCISCO STATION OF THE GREAT WESTERN POWER CO.

The cycle of operation is as follows: The throttle valve latches on the main and house turbines are tripped, causing rapid opening. This operation closes an auxiliary switch which energizes a multi-contact relay device. The slow speed oil circuit breaker on circulating pump No. 2 is opened and the high speed breaker closed. The master drum control is energized and starts the high speed motors on the induced draft fans, opens the solenoid fuel oil valves at the boilers, opens the main valves ahead of the boiler feed regulators, starts the motors of foreed draft fans and changes circulating pump No. 1 to high speed.

A 2500-kw., 2300-v., 3-phase, 60-cycle, noncondensing auxiliary turbine operates normally as a sychronous condenser. Under usual operating conditions, auxiliary power is taken from the main bus through transformers. The house turbine is designed to pick up at full load immediately in case of failure of this power supply and when not carrying load does not require any steam in cooling.

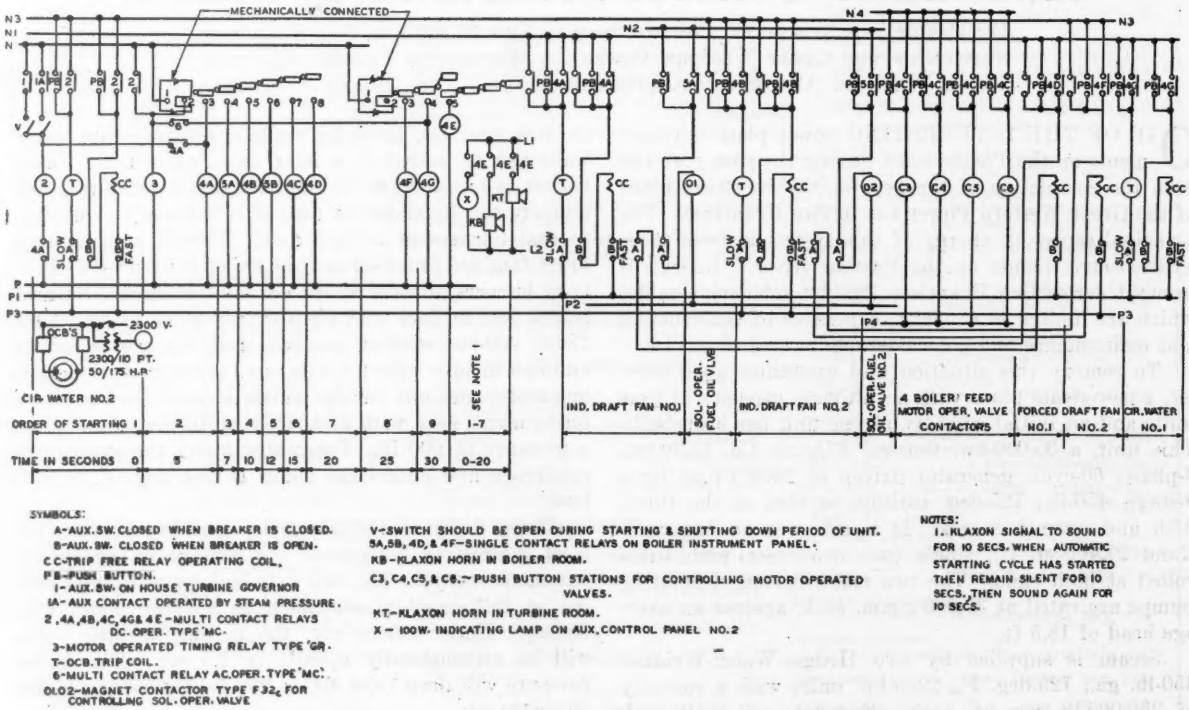
Automatic control equipment consists essentially of the parts listed in the accompanying table and the operating sequence of the automatic starting cycle is as follows, reference drawings and details of the equipment being shown in Figs. 2 and 3. This information is presented through the courtesy of Harold K. Fox, construction engineer of the company.

I. Normal Stand-by Operating Conditions

1. Oil feeds to headers supplying the 20 main burners of each boiler are closed by solenoid operated valves and each furnace is operating on 9 pilot burners.
2. Forced draft fans are shut down.
3. Induced draft fans are operating at slow speed.
4. Circulating pumps are operating at slow speed.
5. Feedwater is bypassed.
6. Auxiliary starting cycle blocking switch V, Fig. 2, is closed.

II. Auxiliary Starting Cycle

1. Auxiliary switch I, Fig. 2, on house turbine governor closes when throttle valve opens due to drop in frequency of approximately 1 cycle.
2. Auxiliary switch I-A on master power member closes when the steam pressure at the throttle drops below 430 lb. per sq. in. ga. and causes master power member in Carrick control to reach "high rating" cut-in point.
3. Either of these switches energizes auxiliary multi-contact MC relay 2 on the Westinghouse auxiliary starting cycle switchboard panel.



SYMBOLS:
A-AUX. SW. CLOSED WHEN BREAKER IS CLOSED.
B-AUX. SW. CLOSED WHEN BREAKER IS OPEN.
CC-TRIP FREE RELAY OPERATING COIL.
PB-PUSH BUTTON.
I-AUX. SW. ON HOUSE TURBINE GOVERNOR
IA-AUX CONTACT OPERATED BY STEAM PRESSURE.
2, 4A, 4B, 4C, 4G & 4E-MULTI CONTACT RELAYS DC. OPER. TYPE 'MC'
3-MOTOR OPERATED TIMING RELAY TYPE 'GR'.
T-OCB. TRIP COIL.
6-MULTI CONTACT RELAY AC. OPER. TYPE 'MC'.
OL02-MAGNET CONTACTOR TYPE F32, FOR CONTROLLING SOL. OPER. VALVE
V-SWITCH SHOULD BE OPEN DURING STARTING & SHUTTING DOWN PERIOD OF UNIT.
5A, 5B, 4D, & 4F-SINGLE CONTACT RELAYS ON BOILER INSTRUMENT PANEL.
KB-KLAXON HORN IN BOILER ROOM.
C3, C4, C5, & C6.-PUSH BUTTON STATIONS FOR CONTROLLING MOTOR OPERATED VALVES.
KT-KLAXON HORN IN TURBINE ROOM.
X-100W. INDICATING LAMP ON AUX. CONTROL PANEL NO. 2

NOTES:
1. KLAXON SIGNAL TO SOUND FOR 10 SECS. WHEN AUTOMATIC STARTING CYCLE HAS STARTED THEN REMAIN SILENT FOR 10 SECS., THEN SOUND AGAIN FOR 10 SECS.

FIG. 2. SCHEMATIC DIAGRAM OF THE AUTOMATIC STARTING CYCLE

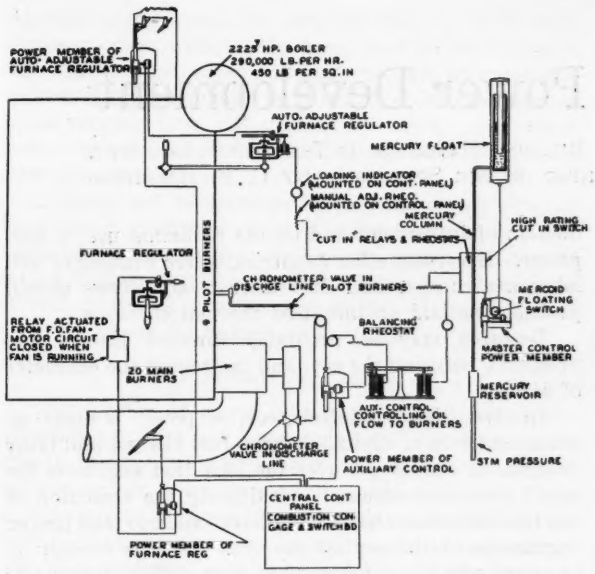

POWER MEMBER OF AUTO. ADJUSTABLE FURNACE REGULATOR
2225 HP. BOILER
290,000 LB. PER HR.
450 LB PER SQ. IN
AUTO. ADJUSTABLE FURNACE REGULATOR
MERCURY FLOAT
LOADING INDICATOR MOUNTED ON CONT. PANEL
MANUAL ADJ. RHEO. MOUNTED ON CONTROL PANEL
MERCURY COLUMN
HIGH RATING CUT IN SWITCH
"CUT IN" RELAYS & RHEOSTATS
FURNACE REGULATOR
9 PILOT BURNERS
CHRONOMETER VALVE IN DISCHGE LINE PILOT BURNERS
MERCOID FLOATING SWITCH
RELAY ACTUATED FROM F.D. FAN-MOTOR CIRCUIT CLOSED WHEN FAN IS RUNNING
BALANCING RHEOSTAT
MASTER CONTROL POWER MEMBER
20 MAIN BURNERS
MERCURY RESERVOIR
AUX. CONTROL CONTROLLING OIL FLOW TO BURNERS
CHRONOMETER VALVE IN DISCHARGE LINE
POWER MEMBER OF AUXILIARY CONTROL
STM PRESSURE
CENTRAL CONT PANEL
COMBUSTION CONTROL GAGE & SWITCHBD
POWER MEMBER OF FURNACE REG

FIG. 3. DIAGRAMMATIC ARRANGEMENT OF THE COMBUSTION CONTROL SYSTEM

4. Relay 2 stops slow circulating water pump No. 2, starts fast circulating water pump No. 2 and also starts the motor-driven drum controller of the Westinghouse GR timing relays.

5. Point 3 on the GR relay drum energizes MC relay 4-A which stops slow induced draft fan No. 1 and starts the fast induced draft fan No. 1.

6. Two seconds later, point 4 energizes HG relay 5-A on the combustion control board, which opens the solenoid operated fuel oil valve to the main burner header of boiler No. 1.

7. Three seconds later, point 5 energizes MC relay 4-B which stops slow induced draft fan No. 2 and starts fast induced draft fan No. 2.

8. Two seconds later, point 6 energizes HG relay 5-B which opens the solenoid operated fuel oil valve for boiler No. 2.

9. Three seconds later, point 7 energizes MC relay 4-C which opens C-3, C-4, C-5, C-6, and the two main and two auxiliary motor-operated boiler feedwater valves for boilers 1 and 2.

10. Five seconds later, point 8 energizes HG relay 4-D on the combustion board which starts forced draft fan No. 1.

11. Five seconds later, point 3 of GR 2 energizes MC relay 4-F which starts forced draft fan No. 2.

12. Five seconds later, point 4 of GR 2 energizes MC relay 4-G which stops slow circulating water pump No. 1 and starts fast circulating water pump No. 1.

13. Point 5 of GR 2 energizes MC relay 4-E for the first and last 10 sec. of the 30-sec. cycle to sound Klaxon horns in the turbine and boiler rooms.

14. If circulating water pump No. 2 is shut down, MC relay 6 is deënergized and relay 4-G is energized and stops slow circulating water pump No. 1 and starts fast circulating water pump No. 1 immediately, ahead of the normal cycle.

15. Relay 4-A remains energized until the master control relay is hand reset and prevents the cycle from repeating.

III. Combustion Control

In the meantime, the Carrick electric combustion control, Fig. 3, starts to function when the "cut-in" relays have been energized as the master power member reaches the "high rating" cut-in point due to the drop in steam pressure.

Cut-in relays throw the air and oil supply power member push buttons onto automatic control and cut-in automatic control rheostats in the ranger coil circuits to adjust the boiler air and oil supply to the righ rate steam demand.

When conditions are again normal the operator adjusts the boiler feedwater valves, stops the fast fans, and resets the cut-in relays and the master relay in anticipation of another power demand.

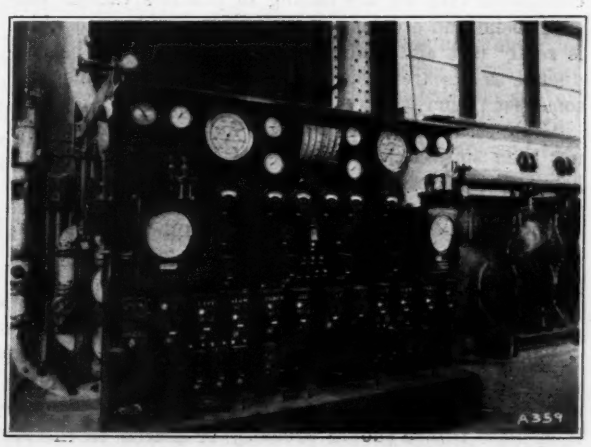


FIG. 4. COMBUSTION CONTROL GAGE BOARD FABRICATED ON THE JOB

AUTOMATIC CONTROL EQUIPMENT

Westinghouse Electric & Mfg. Co. auxiliary starting cycle switchboard panel with two Gr timing relays, six multi-contact d.c. operated MC relays and one multi-contact a.c. operated MC relay.

Carrick Engineering Co. complete automatic electric combustion control consisting of the following items:

1. Furnace regulator and power member for forced draft damper control.
2. Automatic adjustable furnace regulator and power member for induced draft damper control.
3. Auxiliary control and power member for operating chronometer valves in the main burner and pilot burner discharge lines to control oil flow to burners.
4. Mercury reservoir, float and float chamber for registering fluctuations in steam pressure for controlling.
5. Master power member connected to gang rheostats for automatic control of induced draft and fuel oil power members.
6. Hand reset cabinet containing cut-in relays and master relay, energized when master power member reaches "high rating" and closes auxiliary contact starting auxiliary starting cycle.
7. Operating devices on combustion control gage board Fig. 4 (fabricated on the job), including loading indicators, manual control push buttons and automatic cut-outs, automatic to manual transfer switches, manual control and adjusting rheostats and indicating lamps.

The Edward Valve Mfg. Co. two main and two auxiliary 5-in., 600-lb. boiler feedwater globe valves equipped with Dean motor-operated control and Cutler-Hammer seating relays and push buttons.

Ruggles-Klingemann Mfg. Co. two 2½-in. solenoid operated fuel oil valves with Westinghouse two-coil solenoid and Type 32-C magnetic contactor.

Research Relating to Power Development*

RESULTS OF RESEARCH IN PURE SCIENCE ARE THE BUILDING MATERIALS OF TOMORROW'S INDUSTRY. PRACTICAL REQUIREMENTS OF TODAY ARE FAR AHEAD OF THE SCIENTIST. BY C. F. HIRSHFELD

LET ME FIRST make clear that to me research, either in scientific and industrial laboratories, or experimental work done under field conditions in power plants, means an ordered search for truth or for the nearest approximation to truth which may, at the time, be available; a method of attack which is applicable to practically all human activities.

That the results of research in pure science constitute the raw materials of industrial research, which in turn, is the building material of tomorrow's industry, appears to me as clear. We must recognize the necessity of continuing fruitful fundamental research to prevent applied or industrial research from dying of starvation.

Even now, we in the power industry are, in our practical requirements, far ahead of the scientist. We need more knowledge regarding the fundamental composition of matter than the scientist is able to give us. We have advanced empirically far beyond the edges of the field which he has surveyed and properly measured and our results would probably be more cheaply and safely attained, if we had available the more exact and fundamental information that the scientist will some day be able to put into our hands.

ECONOMIC RESEARCH IS IMPORTANT

When we speak of the power industry, it should include production, transmission, distribution; also business, economic and social problems. The last are of at least equal and sometimes of greater importance than the technical features; also, they are just as susceptible of study by research methods.

As an instance, electricity supply organizations may be government owned, operated by government or by a commission, more or less non-political. Stock companies are government, or privately owned, or owned by holding companies whose stock is widely distributed. All forms are widespread in many countries, leading to the conclusion that we are testing in practice various possible social and economic theories. Research as to which is really best and under what conditions must be conducted as a search for truth, not to prove or disprove some pet theory.

Rate structures, admittedly a business problem, have not been subjected to analysis of results to determine how well they have conformed to estimates in competing with individual plants or with other demands on the family purse. What is the proper billing period? Is the customary one month best, considering routine cost, losses on accounts and reactions of the customer?

LOWER INVESTMENT COSTS

There is also plenty of work ahead on the technical side. In the United States, where equipment and labor are costly and fuel is comparatively cheap, stress in the immediate future should probably be placed on the reduction of investment and on the minimum use of man power. In certain other countries, where equipment and labor are cheaper and fuel more costly, stress should probably be laid on increased thermal efficiency.

Research may be profitably directed toward two problems, reducing the cost and improving the character of service.

In the ultimate analysis, cost of power is made up almost entirely of capital charges, fuel charges and labor charges. I cannot get over the idea that engineers the world over have stressed inordinately the reduction of the fuel and labor charges and have failed to take proper cognizance of the capital charges. It is as though investment which was not greater than earlier investments for like capacity was accepted as probably about normal; therefore, I am convinced that the most promising field for research on the technical side, even in countries in which equipment is relatively cheap and fuel relatively expensive, lies at present in the reduction of those charges which are proportional to investment.

The most obvious progress lies in the increase of the size of steam-generating units and in their improvement so as to lengthen the time between necessary shutdowns. When the steam generating part of the plant consists of as few units as the turbine plant and when these can be operated one or two years without shutdown, a radically different type of plant design and a radically lower investment per unit of plant capacity may be expected. German engineers appear to have grasped this idea more firmly than those of any other country. Whether the anticipated new designs come out of their efforts or not, they have at least served to shake us loose from a sort of satisfaction in the methods of the past.

We still use tremendously large and costly furnaces. We still burn stoker iron in addition to fuel, and have to shut down for the purpose of repairing the stoker. We still find maintenance charges and outages of fuel pulverizing mills troublesome. We still have no completely satisfactory method of catching and eliminating fly ash from the stack gases, nor commercial use for such material when we do catch it.

PRECEDENT SHOULD GUIDE, NOT HAMPER PROGRESS

On the electrical end, we still have to face the possibilities of disastrous arcs and other demonstrations of electric power out of control and, to minimize the serious consequences, we make tremendous investments for super insulation and isolation of various sorts. To prevent the concatenated phenomena that so frequently follow upon a minor breakdown, we have used complications, duplications and additions which have all been responsible for increased investment.

As a matter of fact, we have in many of these matters drifted into a sort of blind following of fashion. We are all greatly inclined to do what our predecessor has done, provided he has had reasonably successful results. And, the outcome is, for example, that when one think-

*From a paper before the World Power Conference, Berlin, June, 1930.

ing and original engineer proposes that we shall build a power plant without the huge and costly overhead coal bunkers that we inherit from the days of unreliable coal handling equipment, he is looked at askance because he is varying from the norm. We really need much more original thought of that kind and more departures from the conventional.

I should not be surprised to find the saving effected by reduced investment to be of about the same order of magnitude as the money value of the maximum thermal saving that now appears feasible. If my conclusions are correct, they indicate the desirability of devoting real study to means for reducing investment.

Distributing Cables

Distribution of power is more and more forced underground. Here we invest in costly structures principally because cable is so built that the insulation and not the copper determines the carrying capacity. It is a curious reflection upon our ability as inventors. We start with perfectly good copper conductors which, if left unencumbered, would be capable of carrying certain currents and then we wrap them up in temperamental insulating materials which are so sensitive to temperature that we greatly reduce the carrying capacity of the conductors.

Lowered Labor Costs

Progress in the reduction of labor charges has come about through the use of smaller numbers of units of larger capacity and through improvements which reduced both supervisory requirements and maintenance requirements. Examples of the latter are arrangement of the component parts of power plants so that one man can supervise the operation of the greatest quantity of equipment; automatic feedwater control for boilers; automatic combustion control to a certain extent. We have constructed automatic hydroelectric stations and automatic substations, thus eliminating operators and have installed long distance control of various sorts so that one man can function in one locality as though located in two or more.

These developments indicate that we may be approaching a time when operation will actually be what many dreamers have pictured it, namely, control of all or nearly all functions from a central point by means of indicators and push buttons; research leading toward such accomplishments is certainly justified.

Practice Is Reaching Limitations

And now we come to another set of problems having to do largely with the fuel cost. Although we know what is attainable by present methods, it does not mean that we are now in position to utilize to the full all of the possibilities that we can calculate. In the end, it boils down in each case to attaining, as of the time of a decision, that balance between all costs which represents the best temporary solution.

Use of higher steam pressures and temperatures is extending the economic frontier in the direction of higher thermal efficiency without an offsetting increase in the other items of cost. But we are now beginning to reach limits not previously appreciated. With the high-pressure boiler of conventional design, very minute adhesions of scale to highly active surfaces lead to early failure. Ordinary steels begin to behave like plastic materials at temperatures just above those that we are now using. The glass of water gages proves disappointingly soluble in water at very high temperature. Valve and flange designs which were quite satisfactory for the conditions of five years ago indicate approach to their limits at the present time. Thermal insulation, which was acceptable in the days of moderate steam temperatures, has proved inadequate at the temperatures now in use and it may be that the materials developed for present day use will prove equally faulty with the temperatures that we appear to be about to use. Certain experiences and tests lead some to the belief that water or steam or both may be expected to react, at least with certain steels, at temperatures and pressures of the degree that we are now contemplating.

It may prove possible to obtain a technical solution to each of these and many more problems but a technical solution is not always a commercially usable one.

Better Knowledge of Materials Is Needed

Matters on which we need a much more complete knowledge are the behavior of water and water solutions at high pressures and temperatures, including the change in pH value with increasing temperature, the interaction of water and steam with carbon steel and various alloys, conditions which bring about foaming or priming of boilers and the mechanism of scale formation. We need addition to our knowledge of metals; does creep exist only above a certain temperature or does it become observable only above a certain temperature? Do metals behave as perfectly elastic bodies below a certain temperature, as plastic bodies above a certain other temperature and in some mixed or intermediate fashion between those temperatures? Why is one alloy steel more resistant to creep at a given temperature than another alloy steel? Are tests run for periods of a year indicative of what may be expected over a period of ten years?

At present, design is based largely, if not entirely, upon the theory of elastic behavior. We appear now to be reaching the place where, for many purposes, design will be based upon the permissible deformation in a given or assumed life period. We need new design formulas for such treatment, based upon behavior and strength during plastic flow rather than conditions of perfect elasticity.

Are the intercrystalline cracks commonly found in so-called cases of caustic embrittlement due to the penetration of hydrogen or not? Is this a characteristic of all or only of some steels and steel alloys? What are the causes of other forms or kinds of embrittlement and can they be prevented or their effects minimized?

We need extension of our tabulations of the physical properties of materials. This is now being done for water and steam, but it must be done for many other materials as well. Various accepted tabulations of specific heat, density, thermal conductivity, electrical conductivity show many discrepancies, gaps and inadequacies.

We ought to know a lot more about boiler design, particularly with respect to circulation. What are the exact laws of heat transfer at heat absorbing surfaces and how is the circulation affected by heat absorption of different sorts?

Other problems may become acute as we continue our onward progress. What causes deterioration of lubricating oils and how can they be refined so as to lengthen their useful lives? What is the complete story of the failure of turbine blades? How does it happen that many new turbines experience blade failure, which is later cured by changing the proportions of the blades? How can turbines be so designed as to have greater flexibility with respect to time required for starting yet without unduly sacrificing thermal efficiency?

It seems that much useful information of great practical value lies just outside the reach of the practicing engineer, first because of his lack of familiarity with the newer ideas as to nature of matter and electricity and second, because of a corresponding lack of appreciation of practical needs on the part of those skilled in the new chemistry and physics.

For example, dielectrics are still much what they were two decades ago, empirically evolved through force of circumstances. It would seem that a correct knowledge of the behavior of molecules of different sorts when subjected to characteristic treatments and stresses ought to indicate the direction to be traveled in the production of more satisfactory dielectrics for various purposes.

As another example, we are now in position to calculate, with a fair approximation to the truth, what is ultimately attainable, assuming that the required metals will be available as needed, with the plant cycles now used.

If we may judge from human history, this indicates that we are approaching the end of an epoch; that somewhere around the corner of time lies a radically different process for power development and that, before we have quite reached the limit of possibilities with present methods, the new method will appear as an undeveloped infant to be discussed and fought over and nourished and carried through the period of adolescence until finally we shall all say, "How simple, why did no one think of it before?"

Specific Volume of Air and Flue Gas

CONVENIENT METHOD OF FINDING GAS VOLUME AT ANY TEMPERATURE. BY PAUL F. ANDERSON

FOR ALL PRACTICAL engineering problems, the specific volume of air at 32 deg. F. and atmospheric pressure may be taken as 12.39 cu. ft. per lb. In most combustion computations, the pressure of the air or gas under consideration varies through such small ranges that volumes may be computed on a constant pressure basis.

At constant pressure $V_2 = V_1 \times T_2 \div T_1$ in which T_2 and T_1 are absolute temperatures. Using this equation, we find the specific volume of air at 900 deg. F. as follows:

$V_1 = 12.39$ cubic feet per pound at 32 deg. F. (492 deg. F. abs.)

$T_1 = 460 + 32 = 492$ deg. F. abs.

$T_2 = 460 + 900 = 1360$ deg. F. abs.

$V_2 = 12.39 \times 1360 \div 492 = 34.2$ cu. ft. per lb. at 900 deg. F.

This equation $V_2 = V_1 \times T_2 \div T_1$ is a straight line so that a line drawn between these two points, when plotted to a convenient scale, as shown on the accompanying illustration, enables us to find the specific volume of air at any intermediate temperature without further computation.

Specific volume of flue gas will vary with its composition as well as with its temperature, so it would be impossible to construct a single curve that would show the volume of all flue gases at any temperature. In practice it usually happens that a given plant will burn fuel which varies only slightly from time to time and one or two curves at varying excess air conditions will serve to tell the whole story.

A convenient and easy way to construct these curves is as follows:

Assuming a fuel which when supplied with 22 per cent excess air gives the following products of combustion by weight: $CO_2 = 21.00$ per cent; $O_2 = 3.88$; $N_2 = 71.76$, and $H_2O = 3.36$.

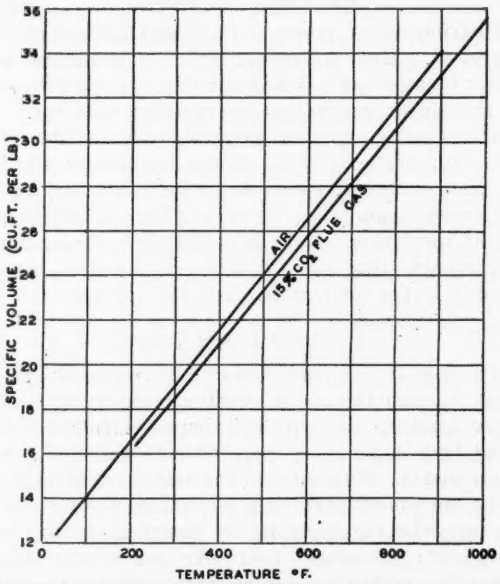


CHART FOR DETERMINING SPECIFIC VOLUME OF GASES AT DIFFERENT TEMPERATURES

Specific volumes of the constituent gases at atmospheric pressure and 32 deg. F. are: $CO_2 = 8.103$; $O_2 = 11.209$, and $N_2 = 12.809$.

Assuming the H_2O content as saturated steam, the specific volume of this gas at 212 deg. F. or 672 deg. F. abs. becomes:

CO_2	$0.2100 \times 8.103 \times 672 \div 492 =$	2.32
O_2	$0.0388 \times 11.209 \times 672 \div 492 =$	.59
N_2	$0.7176 \times 12.809 \times 672 \div 492 =$	12.57
H_2O	$0.0336 \times 26.8^*$ =	.90
		16.38

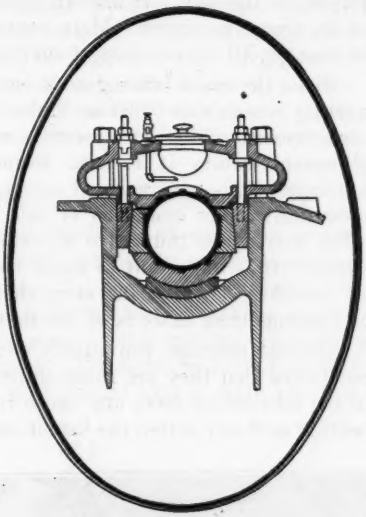
At 1000 deg. F. the specific of this gas will increase to:

CO_2	$0.2100 \times 8.103 \times 1460 \div 492 =$	5.05
O_2	$0.0388 \times 11.209 \times 1460 \div 492 =$	1.29
N_2	$0.7176 \times 12.809 \times 1460 \div 492 =$	27.30
H_2O	$0.0336 \times 59^*$ =	1.97
		35.61

A straight line drawn between these two points, when plotted on the same scale as the air volume, gives a useful curve which approximates all 15 per cent CO_2 (by volume) flue gases.

*Specific volume of steam at respective temperature and atmospheric pressure.

DIESEL ENGINE UPKEEP



PART VII. BEARING WEAR MEASUREMENTS AND COMPENSATION. AVOIDING AND OVERCOMING HOT BEARINGS. REBABBITING AND OTHER RECONDITIONING PROCEDURE. CLEARANCE RECOMMENDATIONS. BEARING KNOCKS

BEARING TROUBLES may be due to incorrect construction, excessive or unequally distributed pressure, contamination of lubricant, incorrect method of lubrication or unsuitable lubricant.

Diesel engine bearing design is fairly well standardized, the workmanship and materials used are generally good but wear occurs and adjustments must be made. Excessive pressures may result from misalinement, heavy belt pull or overload. Contamination of lubricant is now being overcome by use of filters and centrifuges. Improved methods of lubrication, the most important of which is forced or pressure lubrication, in which the bearing is flooded and sensible heat as well as any foreign matter carried away and knocking deadened by the cushioning effect of oil under pressure, have reduced bearing troubles considerably. Hot bearings and pressure lubrication seldom are found on the same engine.

Unsuitable lubricants are being avoided more and more as facts concerning lubricants are being brought out by such national groups as the Diesel Fuel Oil Specification Committee of the A.S.M.E. Oil and Gas Power Division.

EFFECT OF WEAR ON MAIN BEARINGS

If wear is found on main bearings it affects the compression pressure in the cylinder, hence the shims in the crankpin end of the connecting rod must be adjusted if the crank shaft centerline cannot be brought back to its original position, which is the usual case where the bearing cap is merely brought down by the removal of shims. This adjustment is provided by removing shims from the upper part of the crankpin box of a thickness equal to the amount the shaft was lowered.

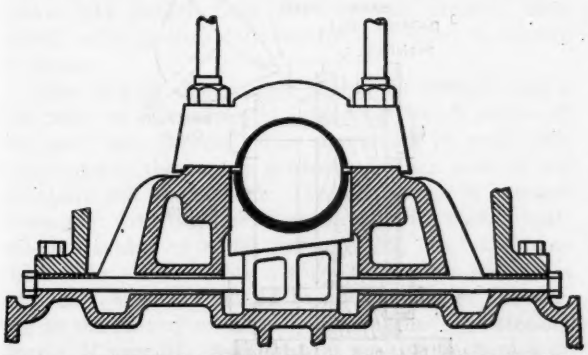


FIG. 1. METHOD OF ADJUSTING MAIN BEARING BY RAISING LOWER PART OF BEARING. ADJUSTMENT MAY BE MADE WHILE ENGINE IS RUNNING

It is desirable, therefore, to keep a record of the amount of shims removed and when they total up to $\frac{1}{32}$ in. slip a compression shim under the foot of the connecting rod equal to that amount, thus restoring the compression volume to its normal amount. Laminated shims, which provide means for removing thin layers of definite thickness, are convenient for this purpose and are obtainable in the market. Adjustment for wear from below, which more nearly maintains constant center to center distance on the connecting rod, hence more uniform compression volume, is illustrated in Fig. 1. In this case wear is taken up on the part which receives the greater pressures; hence which suffers the greater wear.

Main bearings do not wear uniformly, improper lubrication or localization of excessive pressure may cause different parts of single bearing to wear unequally. In a like manner different bearings of a group may be expected to wear at different rates, in time, causing misalinement of the crankshaft as described in the previous article of this series.

End bearings especially, should be watched closely since one carries a flywheel while the other may carry an air compressor. Usually the flywheel has the additional support of an outboard bearing which, if out of line with the other bearings, will suffer from the centrifugal action of the wheel and the misalinement will cause a whipping of the shaft equal to the slack of the caps or, if no slack exists, a bending equal to the difference in the angle, in time causing fatigue and fracture of the shaft.

METHODS OF MEASURING BEARING WEAR

Measurement of bearing wear is most conveniently made by use of the bridge gage as shown in Fig. 2. Bridge gages are furnished with the engines by some Diesel engine builders. A convenient gage for measuring the height of the journal from the bore of the bed when replacing a main bearing is shown in Fig. 3. This gage can be made in any shop. The bottom pin is

riveted to the steel bar and an adjustable screw tapped in its center as shown. Main bearing clearance should be about 0.001 in. per inch of shaft diameter.

Since the main bearing adjacent to the flywheel frequently is set about 0.003 in. higher than the other bearings, because of its more severe service, this slight misalinement causes it to run warmer than the other bearings. This may be used as an indicator of proper operation; cooler operation of this bearing than of the other bearings is indicative of wear that should be adjusted. It is important to check bearing settings every six months. There is far more chance of misalinement of bearings than there is of the shaft.

Because bearings run quietly and do not heat it does not follow that they are functioning properly. A break in the lubrication from any cause results in heating the bearing and may soften the babbit, causing it to be wiped

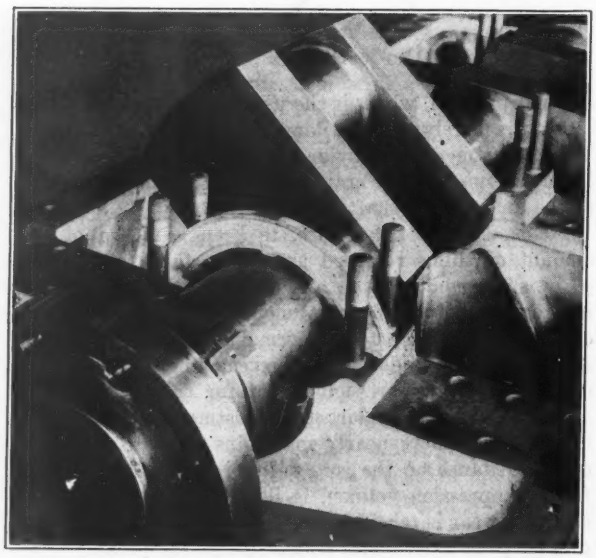


FIG. 2. BRIDGE GAGE SERVES AS MEANS FOR ACCURATE DETERMINATION OF BEARING WEAR

away until the bearing carries no weight. Babbit begins to soften dangerously at between 300 and 400 deg. F. A badly wiped bearing may be detected by removing the cap, when the metal carried around will be observed at the top where it was deposited. Inspection of the lower half may be made by rolling out this half as described in the previous article of this series.

Hot Bearings

Bearings warm up normally due to friction but excess heat is usually dissipated to the surrounding parts and to the air or in pressure systems, it is carried off with the lubricant. Overheating may be caused by excess pressure, unequal pressure or stoppage of the lubricating system. When a bearing becomes abnormally hot the trouble should be ascertained and removed as promptly as possible but no time lost in relieving the excessive heat. The first thing to do when a large bearing heats is to increase the bearing clearance by slacking back the bearing brasses.

If a stop can be made, the bearing that has become overheated should be first flooded with oil to assure, if possible, the existence of an oil film between the journal

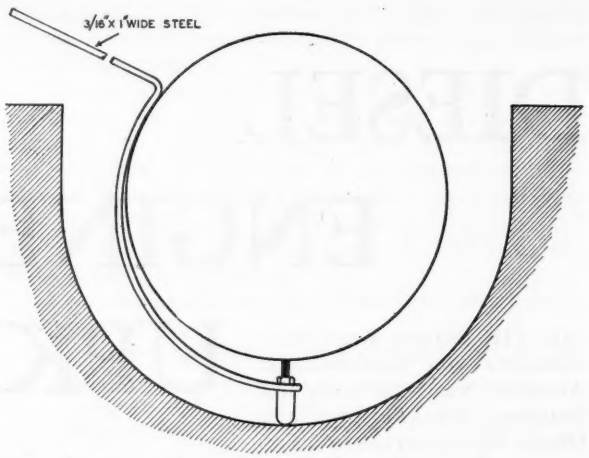


FIG. 3. GAGE USED TO MEASURE HEIGHT OF JOURNAL FROM BORE OF BED WHEN REPLACING A MAIN BEARING

and bearing. If the bearing is very hot the oil regularly used may be so reduced in viscosity that an effective film will not be formed. Heavier oil such as steam cylinder oil should then be used or a little graphite or sulphur mixed with the oil. Crankcase oil that has become saturated with carbon is effective for this purpose. A hot bearing may be relieved by reducing the speed or load. The load on the one cylinder may be relieved by cutting out its fuel feed but care should be taken not to overload the other cylinders. If possible, the two cylinders adjacent to the hot bearing should be cut out temporarily.

Water Cooling May Be Dangerous

Throwing water on a bearing may cause it to seize by the contraction of the bearing thus caused while the journal remains in its expanded condition. As long as mineral oil is used, no water should be applied as it tends to destroy the lubricating effect. If water is used it should be applied to the journal, not to the bearing. Contraction of the shell of the bearing may cause the babbit to be loosened, forming an air pocket between the babbit and shell, which still further reduces the heat conductivity.

Cooling may be induced best by running an oil pipe or hose to the bearing and feeding a heavy stream of cool oil through the inspection hole in the cap directly

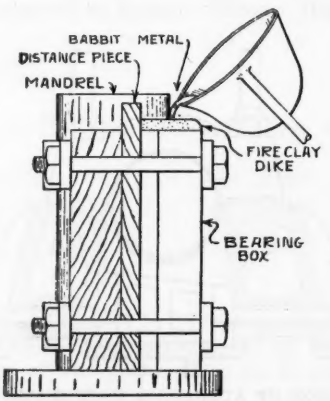


FIG. 4. BABBIT SHOULD BE POURED WITH BOX IN VERTICAL POSITION SO AS TO PREVENT SHRINKAGE HOLES

to the shaft. The oil should be drained off as fast as it is applied so as to make the cooling action of the applied stream more effective.

Although inspection of an overheated bearing may show the oil grooves wiped full of melted babbit, the bearing may still be serviceable. All loose metal should be scraped out and the babbit tapped all over with a light hammer to detect looseness and the bearing examined for cracks. If the metal is tight and unbroken the bearing may be used after renewing its oil grooves and clearances, drilling out its oil holes and scraping it in to fit the journal. If the metal is full of fine cracks it is better not to use it. Single cracks may be repaired by acetylene welding if the babbit is solidly anchored. Oil seals at the ends of the bearing should also be examined to see that they are intact.

Rebabbiting Bearings

High-grade, tin-base babbit is almost universally used in Diesel engine bearings; hence it can be reused for rebabbiting. Whenever possible, the bearing should be cast on end as shown in Fig. 4; therefore the box should be removed from the engine for this purpose.

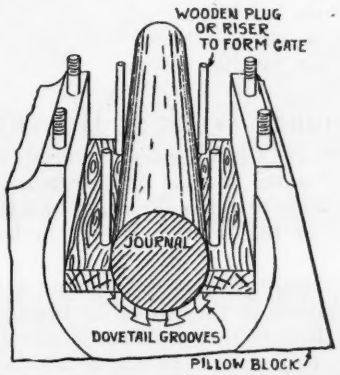


FIG. 5. METHOD OF CLOSING, GATING AND VENTING A BABBIT RECESS IN A PILLOW BLOCK WHEN RE-BABBITING A NON-REMOVAL BOTTOM SHELL

NOTE: A bearing so prepared is tamped with molding sand or fire clay. The plugs are set into notches, which notches later form gates for the babbit.

Preparation of the box for the babbit is extremely important. All boxes to be rebabbited should first be tinned. Tinning is difficult, especially on cast iron, of which most Diesel boxes are made, unless the box has been cleaned thoroughly. The box should be heated to remove old babbit from the dovetail grooves, then washed with gasoline followed by lye water, to remove all grease.

After drying, the surface should be treated with a flux made of muriatic acid into which small scraps of zinc have been thrown. This should not be used until it has become thoroughly neutralized when some of the scraps are still undissolved. The shell should be brushed thoroughly with this flux, then tinned with babbit, half-and-half solder or equal parts of tin, lead and zinc which is brushed on with a wire brush while the box is hot. Sal ammoniac should be sprinkled over the surface as the coating of metal is brushed in. The tinning process, if properly done, insures positive anchorage of the babbit without resort to the uncertain method of peening. The babbit should be cast around a mandrel which is about ¼ in. smaller in diameter than the finished size and then bored to size. If a regular mandrel is not available, one may be made of a piece of pipe with flanges at the ends or, if only one bearing is to be poured, a wooden mandrel covered with heavy paper will suffice. Putty or clay may be used where necessary.

Babbit Should Be Poured Into Heated Box

Proper preheating of the box is of considerable importance as the babbit will not fill the entire space nor stick to the tinned surface if it is chilled too quickly. If it cools too slowly the different metals making up the babbit may separate to some extent and the crystalline structure will not be good. The metal will be of correct temperature if a pine stick dipped into it chars but does not burn. The metal should cool from bottom up and a riser should be provided at the top so that pouring may be continuous and allowance may be made for any shrinkage at the top. A gas torch applied at the top serves well in securing a good casting. The metal should never be overheated.

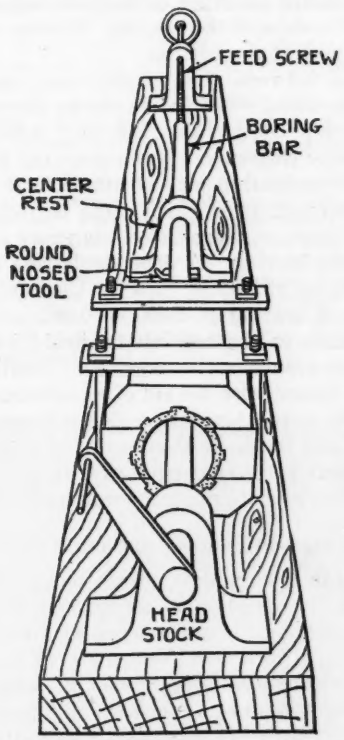


FIG. 6. HANDY JIG MAKES BORING OF BABBITED BEARING, A SIMPLE MATTER

Pouring may be facilitated by the addition to the laddle of a little rosin or sal ammoniac. A little powdered charcoal will protect the surface of the metal from oxidation while heating but the dross should be held in the laddle while pouring. Any small amount of impurity that may go into the mold will settle in the riser; hence will be removed when the riser is broken off.

Centrifugal Method of Casting

Diesel engine manufacturers are now using the centrifugal method of casting babbit bearing by which the mandrel, through which the metal is distributed, rotates

at about 200 turns per min. By this method a clear, uniform and dense casting is assured.

If the box cannot be removed from the engine, closing, gating and venting the mold may be done as shown in Fig. 5. In this case, it is usual to cast the babbit around the journal, in which case the journal is coated with white lead to prevent sticking. Use of a mandrel and subsequent boring is preferable practice where possible. A simple boring device for this purpose is shown in Fig. 6.

In fitting bearings, they should always be "scraped in." This process is best learned by actual performance but a few words of caution may be in place. Whatever material such as red lead is used for indicating the high spots, it should be applied to the journal very thinly. Another important matter is to avoid the tendency to scrape too much metal from any spots, especially from the sides of the bearing. Be sure the journal is touching well at the bottom.

Clearance between the bearing and crank cheek amounting to about 0.007 in. should be allowed. Some engines develop considerable side-play which may be due to excessive clearance. If the clearance is too great, the ends of the bearing may be tinned and a ridge of babbit run around, after which it can be reduced to the desired thickness or a sheet steel ring may be attached to ends of the bearing. A dependable rule for adjusting the clearance of bearing caps is: Clearance in inches = diameter of bearing $\times$ 0.005 + 0.002.

Oil channels in the crankshaft should be examined whenever the crankshaft is removed. Scorings should be carefully stoned with the aid of an oil stone or, in the case of badly scored journals, a fine mill-cut file in expert hands and finish by stoning, is most satisfactory. The grooves are not very dangerous if they are carefully smoothed down so as to prevent breaking the oil film.

Pin Bearings Require Special Attention

Crank bearings require more attention than main bearings. A few simple tools should be kept constantly available, therefore, for pin bearing adjustment. These tools may consist of a heavy wrench to fit the crankbolt nuts, a skeleton wrench to back them off, a small wrench to open up the lock nuts, a pinch bar to "jump" the box at the pin, a set of rope tackles to lift the bolts and chain tackles to handle the boxes on large engines and a sledge hammer.

Existence of slack in a bearing may be determined by "jumping" the box; the amount of slack by the use of two or three leads spaced equally lengthwise of the pin and in a circumferential position on the bottom half of the bearing after it has been lowered. The bottom half then should be drawn up, hammering the nuts on the crank bolts up to their original position as indicated by a reference mark previously made on the nut and bolt. After lowering the box again the leads may be removed and their thickness measured.

Hammering up crank-bolt nuts should be done with care. The bolts should be left neither stretched nor slack. If the amount of shim is reduced, the amount the nut should be turned beyond its original position, as indicated by the reference mark, should be proportional to the amount of shim removed.

Accidents have occurred as a result of broken bolts due either to excessive sledging or to crystallization of the steel caused by pounding operation with loose boxes. Crank-box bolts should be tested for stretch from time to time by measuring and recording their lengths. Some engineers advocate periodical removal and annealing of bearing bolts in order to remove crystallization tendencies. If in such cases the bolts had previously been heat treated, they should be subjected again to that treatment.

Bearing Knocks

Loose bearings are often detected by a slight knock. When starting up, after scraping in a bearing, be careful that it does not run hot. If necessary, slacken the bearing cap nuts and put in an extra shim. Care should be observed also, in installing a new bearing, not to spring the crankshaft more than the slight amount recommended in a previous paragraph.

Slapping of trunk pistons is not a serious matter but where crossheads or guides wear and become too slack, the piston will bear heavily on the cylinder wall and the piston rod assume an angular slant. Under such circumstances, the crosshead should be reset to take up the slack. From 5 to 7 thousandths of an inch is proper clearance on the smallest point of guides if the guide surfaces are not parallel.

Preliminary Work at Hoover Dam

United States Civil Service Commission announces that speed all along the line will characterize the construction of Boulder Dam, christened the Hoover Dam by Secretary of the Interior Wilbur in honor of the President.

When Secretary Wilbur was driving a silver spike to begin operations on the connecting railway, the Commissioner of Reclamation at Washington was authorizing his chief engineer at Denver to appoint 50 engineers, principally civil, and a few electrical and mechanical, for preliminary work on designs and estimates.

The Civil Service Commission is establishing time records in supplying eligibles for these positions. A few weeks after the Commission received the call for the junior engineers, the examination process was completed and the certified eligibles were in the hands of the Commissioner of Reclamation. The higher grades of engineers, for which the call was made later, will be ready for certification in a few weeks more.

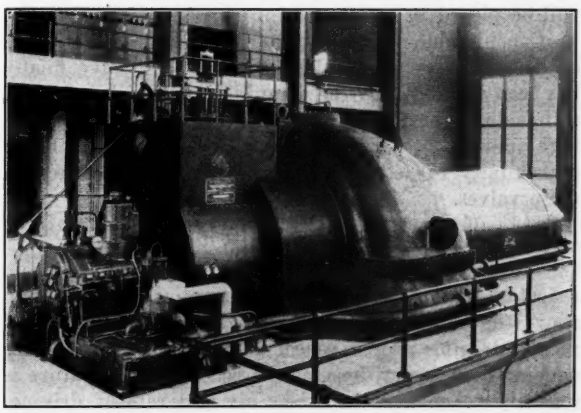
Contracts for preliminary construction and development work will be awarded soon, according to a statement made by the Bureau of Reclamation. Contracts for the major features will not be let for a year or more. The Bureau of Reclamation regards it as necessary to emphasize this to correct a general impression that a large construction force is to be organized at once or is already at work. It is expected that practically all construction work will be let to private contractors. Under this plan the contractors will make the greater number of employments.

This huge engineering task, for which $165,000,000 expenditure is authorized, has three purposes, namely, reclamation of arid lands, power development, and flood control. It is expected that the power generated will be transmitted as far as Los Angeles.

Peak loads in public utility power plants usually occur about six o'clock in the evening.

Plant Atkinson

Georgia Power Co. Completes First 66,667-Kv-a., 425-Lb., 725-Deg. Steam Unit at New Plant on Chattahoochee River near Atlanta, Ga.



Plant Atkinson was designed as a station in which efficiency has been properly weighed against initial investment and fuel costs. It is expected that the following plant economy will be attained: 25 per cent load factor, 17,600 B.t.u. per kw-hr. sent out; 50 per cent l.f., 16,500 B.t.u.; 75 per cent l.f., 15,100 B.t.u.; 100 per cent l.f., 15,400 B.t.u.

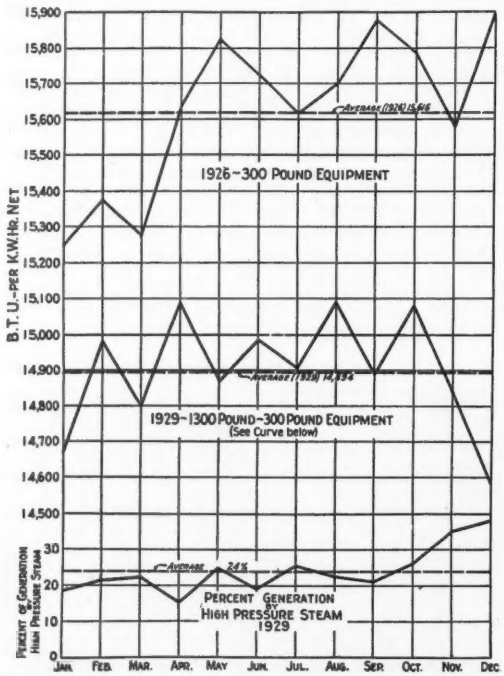
The first unit consists of a 60,000-kw., 1800-r.p.m., 17-stage turbine driving a 66,667 kv-a., 13,800-v., 3-phase, 60-cycle generator. The turbine is bled for feedwater heating at stages 7, 10, 12 and 15 and exhausts to a 70,000-sq. ft. two-pass surface condenser. Steam for this unit is generated at 488 lb., 750 deg. by two cross-drum water tube boilers, each with 30,200 sq. ft. of heating surface. Furnaces have water-cooled side and rear walls and air-cooled front wall, furnace volume 25,120 cu. ft. each, fired by pulverized coal by four 6-t. unit pulverizing mills.

The station was designed by Southeastern Engineering Co. and built by Empire Construction Co., recently absorbed by Allied Engineers, Inc. Further details of the plant were given in the April 15, 1930 issue of Power Plant Engineering. It will be formally dedicated October 17.

High-Pressure Experience Summarized

SEVERAL YEARS' EXPERIENCE WITH 1300-LB. PRESSURE SUMMARIZED IN N.E.L.A. REPORT

HIGH-PRESSURE power plant development which has made such remarkable headway during the past couple of years dates back to the pioneer installation of the Edison Electric Illuminating Co. of Boston at Edgar station and the Milwaukee Electric Railway & Light Co. at Lakeside station. The initial installation at Edgar was closely followed by a somewhat similar installation at Lakeside. Although there are several 1200 to 1400-lb. installations now in service, it is to these


B.T.U.-PER K.W.Hr. NET
1926-300 POUND EQUIPMENT
1929-1300 POUND-300 POUND EQUIPMENT
(See Curve below)
PERCENT GENERATION AT HIGH PRESSURE STEAM 1929
PERCENT OF CONDENSATION HIGH PRESSURE STEAM
Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. Dec.

CURVE SHOWING IMPROVEMENT OF LAKESIDE STATION PERFORMANCE AFTER ADDING 1300-LB. EQUIPMENT

two pioneer stations that we must go for data regarding the experiences over an extended period.

At Edgar during the year 1929, two 1400-lb. boilers and one 12,500-kw., 1350-lb. steam turbine along with the necessary auxiliaries were installed and placed in operation. The turbine has five steam admission valves and has given considerable trouble from valves sticking. The manufacturer has recently installed a new valve stem packing design which gives promise of satisfactory performance. In all respects, other than valve sticking, this unit has given satisfactory service.

High-pressure feed pump troubles have continued. Pump shafts have broken with considerable regularity and the pump casings have cut out between pressure chambers at the high-pressure end of the pumps. These pumps have a horizontal joint and are to be replaced by pumps with castings of the barrel type. On account of feed pump trouble, the high-pressure heater was kept out of service practically all of the time. This heater, when in operation, is fed with steam at 360 lb. ga. pressure from the high-pressure turbine exhaust, temperature of water leaving heater being normally 430 F. While the heater was in operation, considerable difficulty was experienced with pipe joint leakage and it seemed that feed pump troubles were accentuated. After the new feed pumps are installed, the high-pressure heater will be placed in service again.

Considerable difficulty was experienced with sticking of boiler feedwater regulating valves. A valve finally has been developed by the manufacturer which has given satisfactory service on 300 deg. F. water. After the high-pressure heater is back in service, there will be an opportunity to determine the effect of hotter water on these valves.

REHEAT HARD TO REGULATE

Two boilers installed during the past year have steam reheaters of the convection type installed in the setting above the boiler. Some difficulty has been experienced in maintaining proper reheat steam temperature under varying firing conditions, as the reheater temperature is sensitive to changes in excess air and rate of driving. A small gas bypass was installed around these reheaters, but this gives practically no regulation and is left open at all times in order to reduce the reheat temperature as much as possible. It has been necessary to install desuperheaters ahead of these reheaters in order to reduce the reheated steam temperature. Under certain adverse firing conditions, it is impossible adequately to reduce the reheat temperature, with all the desuperheater capacity in service, for bringing the steam down to saturation temperature before entering the reheater.

To help reduce the reheat temperature on boilers 7 and 8, steam is diverted from boilers 5 and 6. This reheater operating difficulty is believed to be due to faulty stoker performance and faulty proportioning of heat absorbing surface in the steam generating unit. Boilers 5 and 6 were designed for the same maximum output as boilers 7 and 8, but the boiler heating surface of 7 and 8 is less than one-half that of boilers 5 and 6. Removal of reheater surface from boilers 7 and 8 would reduce the reheat temperature and increase preheated air temperature which is already higher than the stokers can stand. This change would also increase economizer heat absorption which seems to be undesirable on account of boiling. The placing in service of the high-pressure heater will increase the economizer exit temperature and air preheat. After the high-pressure heater is back in service again, a study will be made and steps will be taken to remedy the troubles.

Present methods of determining water level in the high-pressure boilers are unsatisfactory on account of the difference in density of hot and cold water. The difference in level in a gage glass before and after blowing down has in some cases amounted to as much as 5 in. This has a tendency to cause high water during opera-

tion. From an operating point of view, high pressures are considered somewhat more difficult to handle than lower pressures on account of complications in plant design, but it is believed that none of the difficulties are insurmountable.

Experience at Lakeside also extends over a period of several years and can be summarized in concise manner as follows, under three main headings.

Continuity of Operation

The 1300-lb. boiler operated 85 per cent of the available hours in 1929 and 75 per cent of its 3-yr. life, completed in October, 1929. The third four-month continuous operating period occurred during the year (1929). Interruptions to continuous service were almost entirely occasioned by repairs to the 300-lb. pressure reheater. The boiler has operated 16,000 hr. without internal cleaning and apparently will operate indefinitely without turbining while the high-pressure turbine availability has been 100 per cent.

Economy

Generation by high-pressure steam from the one high-pressure boiler totaled 22 per cent of the station output for the first 10 mo. of 1929 (before the second high-pressure boiler was placed in operation) and considerably bettered the 300-lb. section efficiency. No change in turbine efficiency has occurred but the boiler feed pump efficiency is not maintained over long periods without replacement of parts usually ranging between 50 and 55 per cent although it has reached as low as 40 per cent in the original pumps.

Operating Experiences

High-pressure piping joint failures have been limited to the single one that occurred upon starting in 1926. Chemical deaeration of feedwater was developed to diminish oxygen in the feedwater to zero at all times. An embrittlement specimen stretched above its elastic limit continues unaffected within the initial boiler. Dependence is placed upon sodium phosphate, at all times in the boiler water, to inhibit embrittlement.

Turbine clogging troubles, that is deposit upon the turbine blades bothersome sometime ago, reappeared, upon operation of the second high-pressure boiler, at 0.6 per cent moisture carryover. This was corrected only upon maintaining the total solids in the boiler water below 100 p.p.m.

Combination of radiant superheater and convection reheater on the second installation is more desirable than having both surfaces of the radiant heat absorbing type as in the original installation. Pressure drop measurements across the new 1300-lb. round tube radiant superheater indicate that the Babcock formula gives results 90 per cent too high for this pressure. The actual pressure drop is 18 lb. in contrast to the 35 lb. which was expected.

Essentially the only unsolved high-pressure problem is the failure of the high-pressure extraction heater tubes which is still occurring.

During the past year, the second high-pressure unit similar to the first one was added and two more units of the same type are being installed this summer. Data shown in the curves indicate the benefit derived from adding the 1300-lb. equipment to Lakeside station. It may be seen that the generation of 24 per cent of the steam at high pressure and the utilization of this steam improved the station heat consumption by 721 B.t.u. per net kw-hr. On the basis of identical heat consumption of the 300 lb. section the two years under comparison, these data indicate that the 1300-lb. equipment is 19 per cent more efficient.

A. S. M. E. Elects Roy V. Wright President

Election of Officers of The American Society of Mechanical Engineers for 1931 was announced by the Tellers of Election on September 23, 1930, after canvassing the ballot of the membership. List of the new officers of the Society follows: President, Roy V. Wright, Managing Editor, Railway Age, New York. Vice-Presidents, William A. Hanley, Chief Engineer, Eli Lilly Co., Indianapolis, Ind.; Thomas R. Weymouth, President, Oklahoma Natural Gas Corp., Tulsa, Okla.; Harvey N. Davis, President, Stevens Institute of Technology, Hoboken, N. J. Managers, W. L. Batt, President, S K F Industries, Inc., New York, N. Y.; H. L. Doolittle, Chief Designing Engineer, Southern California Edison Co., Los Angeles, Calif.; H. L. Whittemore, Chief, Engineering, Mechanics Section, Bureau of Standards, Washington, D. C. Representatives American Engineering Council: W. R. Webster, Bridgeport, Conn.; R. V. Wright, New York, N. Y.; J. W. Roe, New York, N. Y.; Robert Yarnall, Philadelphia, Pa.; E. N. Trump, Syracuse, N. Y.; B. E. Hull, Houston, Tex.; E. O. Eastwood, Seattle, Wash.; W. Trinks, Pittsburgh, Pa.; Warner Seely, Cleveland, O.; and William S. Conant, Washington, D. C.

Henry Ford has obtained from The New York Edison Co. for his Museum of American Industries the only remaining dynamo that was part of the original equipment designed and built by Thomas A. Edison for the world's first central station of the electric light and power industry, the old Pearl Street Station, New York City. Mr. Edison installed six dynamos in this first station, which began operation September 4, 1882. About two years later, two more machines were installed on account of growth of business. Seven were lost in a fire that partly destroyed the original station, January 2, 1890.

These dynamos, which were much larger than any known up to the time of their manufacture, were called Jumbos. The one saved was known as Jumbo No. 6. It has been in the possession of The New York Edison Co. and on Tuesday, September 9, Ford Co. trucks carried it to the Ford assembly plant in Long Island City, where it will be crated for shipment to the Museum. Accompanying the dynamo is the Armington & Sims engine that furnished steam to operate the machine. According to a letter from Mr. Ford's office, "it is Mr. Ford's idea to build a part of Pearl Street Station in which to install the relic." The unit, consisting of engine and dynamo, weighs about 30 t.

At the time they were built, the Jumbos were rated at 1200 16-candle power lamps and later were run up to 1750 16-candle power lamps. Each Jumbo had a generating capacity of approximately 125 hp. Today single machines have a capacity exceeding 200,000 hp.

Protection *and* Metering *for* Three-Wire Circuits

By JOHN AUCHINCLOSS
Switchgear Engineering Department
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In the operation of alternating current circuits it is often desirable to employ a 3-wire scheme similar to the Edison 3-wire direct current system to obtain voltages half that of the circuit voltages. Such three wire alternating current circuits possess many advantages and they have come into extensive use. In this article Mr. Auchincloss presents a remarkably clear discussion of the principles involved in the operation of such systems and describes methods in use for metering and protecting them.

IN THE DAYS of direct-current distribution for lighting purposes a considerable economy in conductor copper was achieved with the advent of the so-called Edison three-wire system. The voltage of lighting mains was thereby raised from 110 to 220 v. while the neutral wire permitted the continued use of the standard 110-v. lamp. Except for a limited application, more especially in the field of mine haulage, certain industrial specialties, also in electrolytic and other chemical processes, the use of direct current for general purposes has been gradually declining. Inasmuch, however, as many of the problems connected with the Edison system are analogous to those encountered in three-wire single-phase distribution, it may be appropriate to touch briefly upon the former under the heading of this article.

If two 110-v. lamps be connected in series across a 220-v. circuit, as shown in Fig. 1, both lamps will glow at full brilliancy provided their resistances are of equal value, since then each lamp will consume exactly one-half of the total line voltage, or 110 v. per lamp. On the other hand, if their resistances are not equal their voltage consumptions will also become unequal and the connection point between them will no longer lie midway in voltage between the positive and negative lines. Such a condition would arise were a 110-v., 25-w. lamp connected in series with a 110-v., 50-w. lamp. In this case, the 25-w. lamp would receive a voltage much in excess of its rated value while the 50-w. lamp would receive much less voltage than its normal rating requires. It will be seen, therefore, that the brilliancy of the 25-v. lamp would be much above normal just as the 50-w. lamp would glow considerably below its normal intensity.

If, however, the mid-connection point between the two lamps were connected back to a mid-point of the generating system voltage, as shown in Fig. 2, each half of which is capable of maintaining the proper rated voltage on the lamps, the discrepancy in the proportional brilliancy between the lamps will at once disappear due to their current difference flowing over the middle or neutral wire, thereby restoring their respective voltage to normal rated value. Were the lamps shown in Fig. 2 of equal resistance, the neutral wire would obviously carry no current and it is clear that the current which it may be called upon to carry is the difference between the current taken by each lamp at its rated voltage; consequently the closer the equality of the burdens applied to each side of the system the less current will be carried over the neutral wire and the smaller its cross-section may be. This method, therefore, requires sufficient copper to carry only the current of a 220-v. load plus a small additional amount to carry the differential current in the neutral. Obviously, the same load fed from a 110-v., two-wire line would require, if we neglect the small amount necessary in the three-wire neutral, twice the copper required by the three-wire system.

From the foregoing, it is clear that as the difference between the burdens imposed upon each side of the three-wire system becomes greater and greater the larger and larger the cross-section of the neutral wire must become, until it approaches and equals the current-carrying capacity of the positive and negative lines. If, therefore, the neutral wire is designed to carry only a fraction of the current flowing over the outer wires it is clear that under badly balanced conditions it may become seriously overloaded. On a normally balanced system maximum unbalance would obviously arise if one of the outer lines became accidentally opened, by the blowing of a protective device or otherwise, thereby disconnecting the entire load of one side of the system, in which case the neutral conductor would be called upon to carry the full current of the remaining closed line. To prevent the possibility of such an occurrence, with its attendant danger to the neutral conductor, it is imperative that all interrupting devices, whether automatic or otherwise, be of such a nature that their opening will simultaneously disconnect both outer sides of the system.

In a few applications, such as in some classes of marine work, where it is desired to maintain full service on one side of the system while the other is disabled, the neutral of the system may be of sufficient capacity to carry the entire current of the outer wire. In these

circumstances, the above rule can not be applied and single-pole interrupting devices in the outer conductors become necessary.

The preceding discussion involved the possible destruction of the neutral conductor. In that which follows, the possibility of endangering the filaments of one-half the connected lamp load will be considered.

Referring to Fig. 2, it has been shown that the presence of the neutral wire equalizes the voltages across both sides of the system; conversely, its omission destroys the voltage equilibrium, thereby impressing a much higher voltage on the more lightly loaded side of the circuit. Consequently if, during a period of considerable load unbalance the neutral conductor of the system should open, by automatic means or otherwise, there exists a condition of grave danger to the lamp load connected across the less-loaded side of the system, resulting from the increased voltage impressed upon it. To avoid this danger, it is important that the integrity of the neutral wire be at all times maintained. For this reason, fuses or other protective devices in the circuit of the neutral conductor are not to be recommended.

On direct current systems, the neutral point is derived and maintained in various ways the most common of which are shown in Figs. 3 to 6.

From the three-wire direct current Edison system to the more modern three-wire alternating-current single-phase system is but a short step. The derivation of the neutral on the latter is very simple. In Fig. 7, let an auto-transformer having a 220-v. winding be connected across two lines having a 220-v. alternating potential difference between them. If the winding of this auto-transformer be equipped with a mid-tap, this mid-point may obviously be used as the neutral of a three-wire load, across which the proper voltage will be maintained regardless of balance provided the capacity of the auto-transformer, or "balance coil," is not exceeded.

Suppose, for example, a load of 5 amp. be applied to the X side of the system and a simultaneous load of 10 amp. be applied to the Y side. The distribution of current in the two outside wires and the neutral will then be as shown in the figure, the neutral wire O carrying the difference between the currents carried by the line wires X and Y. By taking the particular instant of time when the voltage of primary wire 2 is positive to primary wire 1 the instantaneous flow of current in the secondary wires X, Y and O and the transformer winding may be readily traced. From a glance at these current arrows, it is apparent that the 5 amp. flowing in neutral wire O divides at the mid-point of the transformer winding, 2.5 amp. of it flowing towards line 2 and 2.5 amp. towards line 1. At line 2 this 2.5 amp. adds to the 7.5 amp. coming in over line 2 to form the 10 amp. flowing down over line Y while at line 1 the remaining 2.5 amp. adds to the 5 amp. returning over line X to form the 7.5 amp. flowing back over line 1 to the source of power.

Since the number of transformer turns on each side of the mid-tap are equal while the load amperes flowing through them are also equal but in opposite direction, it follows that their magnetic effects cancel, leaving the magnetizing current as the only flux-producing current in the winding. For the sake of simplicity, the magnetizing current is not shown in the figure. From the foregoing, it is apparent that to carry the secondary unbalanced burden of $10 \times 110 = 1100$ w. plus $5 \times 110 = 550$ w., or a total of 1650 w., the winding of the auto-transformer need have a current-carrying capacity of only 2.5 amp. Were the secondary burden exactly balanced, that is, 7.5 amp. on each side, obviously no load current whatever would flow in the winding of the auto-transformer since there would then be no current in the neutral wire. Under these conditions, the current in line 2 would flow directly out over line Y and return over lines X and 1.

Suppose now that under load conditions similar to those shown in Fig. 7, a two-winding transformer instead of an auto-transformer be used; it is rather interesting to note the current conditions in the separate windings of the two-winding transformer. These are shown in Fig. 8.

From this figure, it will be noted that instead of a current carrying capacity of 2.5 amp. to take care of

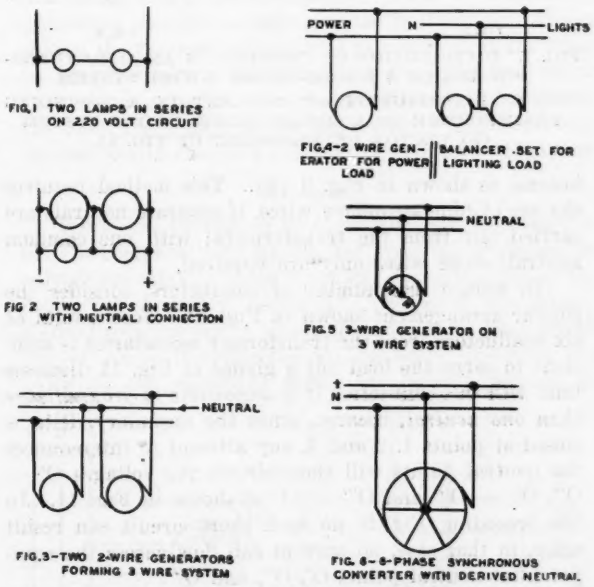
FIG.1 TWO LAMPS IN SERIES ON 220 VOLT CIRCUIT
POWER
N
LIGHTS
FIG.4-2 WIRE GENERATOR FOR POWER LOAD
BALANCER SET FOR LIGHTING LOAD
FIG 2 TWO LAMPS IN SERIES WITH NEUTRAL CONNECTION
NEUTRAL
FIG.5 3-WIRE GENERATOR ON 3 WIRE SYSTEM
NEUTRAL
FIG.3-TWO 2-WIRE GENERATORS FORMING 3 WIRE SYSTEM
FIG. 6-6-PHASE SYNCHRONOUS CONVERTER WITH DERIVED NEUTRAL

FIGS. 1-6. DIAGRAMS SHOWING METHODS OF DERIVING NEUTRAL POINT IN DIRECT CURRENT SYSTEMS

this unbalanced load, the two-winding transformer must be prepared to carry 7.5 amp. in its primary winding and as high as 10 amp. in one-half of its secondary. Obviously, then, for this service the two-winding transformer is much more costly, not only on account of its double winding but also on account of the much greater current which these windings must carry. When the primary voltage is relatively high, however, such as 2300 v., stepping down to the same secondary three-wire voltage of 220/110, the discrepancy in cost practically vanishes. But other expendient than cost then enter the problem, the greatest of which is probably the insulation of the three-wire system from the high voltage of the primary lines. The function of the auto-transformer in distribution work is therefore, chiefly confined to the field of providing a neutral for a system of ordinary service voltage; but, for this purpose, it is preëminently suited.

To balance the loading on a three-phase system, the single-phase, three-wire circuits are frequently distributed as shown in Fig. 9 (a).

If it is desired to ground the neutral, as is required by many regulatory bodies, the three neutral points O may be interconnected and grounded. Vectorially this method of distribution is shown at the right of the figure. Due to the fact that the delta-corners are open on the secondaries of the transformers, it is readily seen that all three points O may be interconnected without causing any flow of current since there is no other connection between the phases and point O′ O″ and O‴ are at the same potential, so that the voltages really become as shown in Fig. 9 (b). This method requires the use of nine secondary wires, if separate neutrals are carried out from the transformers; with one common neutral, seven wires only are required.

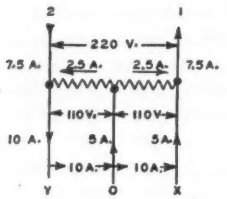

FIG. 7

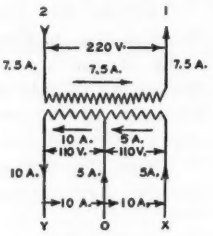

FIG. 8

FIG. 7. DISTRIBUTION OF CURRENT IN AN AUTO TRANSFORMER ON A SINGLE-PHASE, 3-WIRE SYSTEM

FIG. 8. DISTRIBUTION OF CURRENT IN A 2-WINDING TRANSFORMER ON A SINGLE-PHASE, 3-WIRE SYSTEM (B) VECTOR DEVELOPMENT OF FIG. 9A

To reduce this number of conductors, consider the similar arrangement shown in Fig. 10. Here a total of six conductors from the transformer secondaries is sufficient to carry the load but a glance at Fig. 11 discloses that with this connection it is *impossible to ground more than one neutral,* because, since the secondary delta is closed at points 1, 2 and 3, any attempt to interconnect the neutral points will short-circuit the voltages O′ — O″, O″ — O‴ and O‴ — O′ as shown in Fig. 11. In the preceding Fig. 9, no such short circuit can result since, in that case, no current can flow across the equipotential neutral points O′, O″, and O‴.

In most generating stations, the emergency lighting circuits are normally fed from the a.c. voltage of the station lighting system. Frequently this takes the form of single-phase, three-wire service. In the event of severe trouble shutting down the station, however, thereby deënergizing the normal a.c. supply, an automatic throwover switch is generally provided to transfer the emergency lights immediately to a live source of supply such as the exciter or battery bus. To accomplish this, a triple-pole double-throw switch connected as shown in Fig. 12 is usually employed. Normally this switch is latched in the down position against a spring thereby connecting the emergency lights to the a.c. station supply. Should this supply fail, however, the release coil, through lack of voltage, automatically trips the latch and the spring throws the switch to the upper position. The emergency lights are then energized from the exciter or battery as the case may be. The scheme looks simple enough but there is one feature about it which should not be overlooked. On the downward throw of the switch, if the emergency lighting load is fairly well balanced, practically no current or at most only the differential current will flow over the middle wire O. On the upper throw, however, the negative wire is not a true neutral and it will, therefore, be called upon to carry not the difference but the *sum* of the currents flowing in the two outside positive wires. This should not be forgotten in apportioning the conductor capacity on the emergency lighting circuit nor in choosing the ratings of the fuses applied to the switch clips.

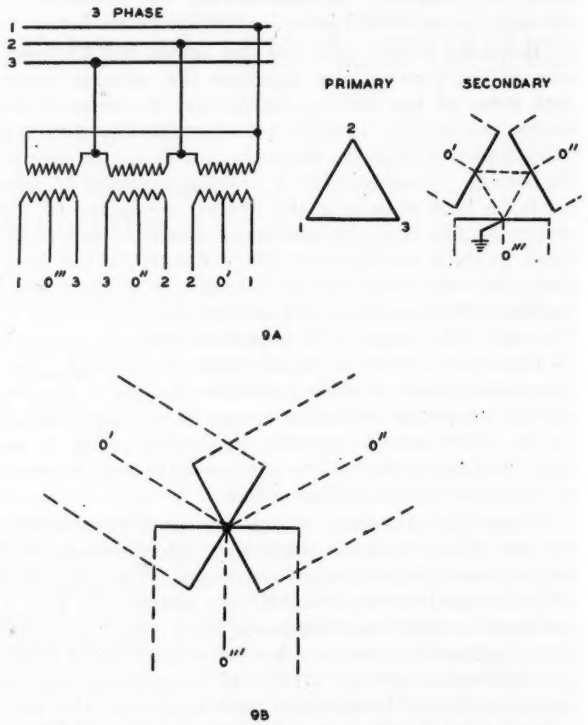

FIG. 9. THREE SINGLE PHASE, 3-WIRE CIRCUITS WHERE NEUTRAL CAN BE COMMON AND GROUNDED WITH CORRESPONDING VECTOR DIAGRAMS

On three-phase, four-wire systems, a so-called three-wire, single-phase lighting circuit is frequently tapped from one phase of the polyphase system, as shown in Fig. 13. In reality, however, this circuit consists of two single-phase circuits displaced 120 deg. in phase and although the middle wire is equidistant in voltage from the two outer wires, it nevertheless carries the vector sum of the currents in the two outer wires. For example, if the outer wires each carry 5 amp., the current in the middle wire is $2 \times 5 \times \text{Cos } 60 = 5$ amp. Also,

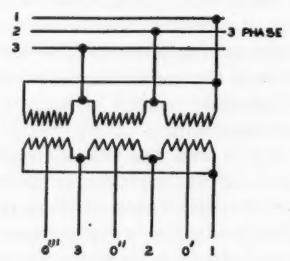

FIG. 10

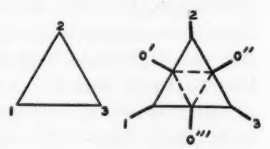

FIG. 11

FIG. 10. THREE SINGLE-PHASE, 3-WIRE CIRCUITS WITHOUT COMMON GROUNDED NEUTRAL

FIG. 11. VECTOR REPRESENTATION OF FIG. 10 SHOWING WHY NEUTRAL CANNOT BE GROUNDED

the voltage between the two outer wires alone is 2 × 110 × Cos 30 = 190 v.

Occasionally two separate single-phase three-wire loads are taken, by means of auto-transformers, from a three-phase bus. Diagrammatically the scheme is illustrated in Fig. 14. In designing the copper connections on the primary or bus side, it should be remembered that the wire connected to bus 2 must carry the vector sum of the currents in primary lines 1 and 3. This is due to the fact that these latter currents arrive at phase

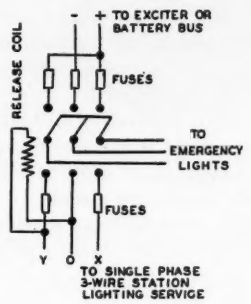

FIG. 12

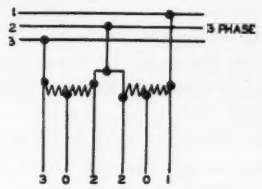

FIG. 14

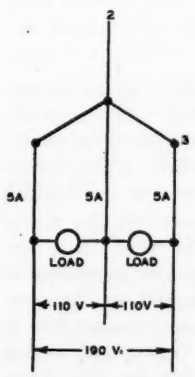

FIG. 13

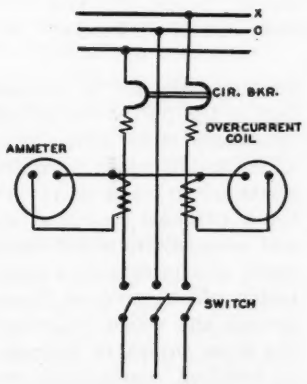

FIG. 15

FIG. 12. AUTOMATIC THROW-OVER SWITCH FOR EMERGENCY LIGHTS

FIG. 13. SO CALLED SINGLE PHASE, 3-WIRE LOAD TAKEN FROM A THREE-PHASE, 4-WIRE SYSTEM

FIG. 14. TWO SINGLE PHASE, 3-WIRE CIRCUITS TAKEN FROM A 3 PHASE BUS

FIG. 15. CONTROL EQUIPMENT FOR A SINGLE-PHASE, 3-WIRE CIRCUIT

2 with a displacement of 60 deg. from each other so that their vector sum is 2 i cos 30 or 1.732 i, where i is the current in primary lines 1 and 3.

Protection

Since the neutral of a single-phase three-wire system is usually grounded, faults may occur not only between the outer wires but also between each outer and ground. For this reason, overcurrent protection must be provided in each of the outer lines to cover all contingencies. As previously stated, however, any overcurrent occurring on one side of the system must automatically disconnect both sides simultaneously so as to prevent overloading the neutral wire with the full line current of the unaffected side. Protective breakers, therefore, should be double-pole with an overcurrent coil in each pole as shown in Fig. 15. On switchboard panels ammeters are usually provided in both the outer lines so that independent readings of the current in each side of the system may be obtained. Occasionally, especially on balancer sets where a knowledge of the amount of unbalancing is quite important, one ammeter in the neutral wire equipped with a zero center scale is often employed. In the majority of cases, however, no overcurrent protection in the neutral is necessary, nor is it even desirable unless its actuation automatically disconnects all three lines.

Since the capacity of balancer sets and the balance coils of three-wire d.c. generators is limited to a value much below the overcurrent setting of the outer protective devices a voltage balance relay is frequently applied to the three-wire bus. Any unusual voltage unbalance, which of course follows from current unbalance in the load, will close the relay contacts and thereby disconnect the three-wire system. Since a momentary unbalance usually accompanies the switching-on of one side of the three-wire load, it is necessary that the relay be provided with a time-delay feature which will allow such switching to be accomplished without disconnecting the load, but which at the same time will not prevent its isolation in case of a substantial sustained unbalance.

Metering

While the protection of three-wire, single-phase circuits is comparatively simple, the metering problems involved are slightly more complex, depending upon the degree of accuracy required. The most elementary method requires only a single-element meter, the current coil of which is connected in one outer line with the potential coil energized across the outside voltage, as

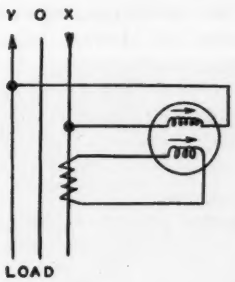

FIG. 16

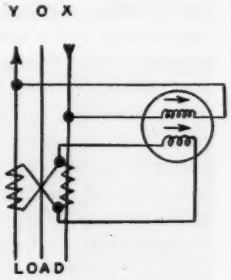

FIG. 17

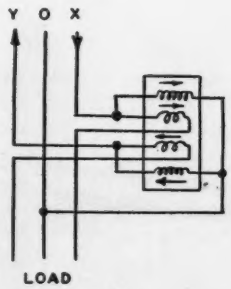

FIG. 18

FIG. 16. SIMPLE METERING OF SINGLE PHASE, 3-WIRE POWER

FIG. 17. MORE ACCURATE METHOD THAN THAT SHOWN IN FIG. 16

FIG. 18. MOST ACCURATE METHOD OF METERING SINGLE PHASE 3-WIRE POWER

shown in Fig. 16. Obviously this method to be accurate must assume equal currents in lines X and Y with no current in the neutral wire O, otherwise its registration may be quite inaccurate. For example, if 10 amp. flow in line X and 5 amp. in lines O and Y the meter, at unity power factor, will register at the rate 10 × 220 or 2200 watts, whereas, the true rate should be only 10 × 110 plus 5 × 110 = 1650 watts, provided the voltages are balanced.

A more accurate reading with the same meter may be obtained by the use of the two current transformers connected as shown in Fig. 17. Here the currents in lines X and Y are added together by means of the cross-connection and the meter registers at the rate (i_x plus i_y) × 220 × 0.5. The multiplier 0.5 must be used since otherwise the meter would register 100 per cent high. It may be avoided by energizing the potential coil of the meter from the voltage of either line to neutral. Neither registration, however, (i_x plus i_y) × 220 × 0.5 or (i_x plus i_y) × 110, takes into account any unbalance that may exist between the voltages O X and O Y. For example $i_x \times e_{ox}$ plus $i_y \times e_{oy}$ may be quite different from $(i_x + i_y)\, e_{xy}$. Furthermore, when no current transformers are available, this connection obviously cannot be used. To measure as shown in Fig. 17, but without transformers, a meter having two primary current coils must be provided. From such a two-current coil device, it is but a step to the complete metering arrangement shown in Fig. 18. From this figure, it is apparent that the registration is correct, regardless of current or voltage balance, since all are duly measured by the meter, which integrates $i_x \times e_{ox}$ plus $i_y \times e_{oy}$ at unity power factor. It should be noted that though the arrows in the upper potential and current coils are instantaneously in the opposite direction from those in the lower coils the torque of both upper and lower elements are nevertheless positive or forward. Since this type of meter measures both the magnitude and phase of each voltage and current, it may be used successfully on any single-phase three-wire circuit.

EDITOR'S NOTE.—This is the first of two articles on the subject by Mr. Auchincloss. The second dealing with polyphase circuits will appear in a subsequent issue.

Motors for Driving Ammonia Compressors

MOTORS NOW AVAILABLE CAN BE SUITED TO ANY TYPE OF AMMONIA COMPRESSOR. BY C. T. BAKER*

SINCE THE DEVELOPMENT of the raw water ice making plant, which has almost completely replaced the earlier distilled water type of plant, the electric motor and the Diesel engine have very largely replaced steam for driving the compressor. Not only has the method of driving the compressor undergone a change, but likewise, methods of driving the auxiliaries, such as condensing water circulating pumps, air blowers, brine agitators, etc., have also undergone a change and are now usually direct connected to electric motors, or in some instances, group driven from a belt wheel located on the shaft of the Diesel engine, where this type of power is used. This article, however, is confined to a treatment of the motor driven compressor.

In the earlier applications of motor drive to ammonia compressors, the belted type motor was employed. This permitted the use of comparatively high speed motors due to the pulley ratios selected, thus permitting the compressor to be driven at speeds not greatly in excess of the speeds which prevailed in the case of the earlier steam driven compressors. Due, however, to the demand for a practical means of direct connecting the motor and compressor, motor manufacturers were, in a few years, able to develop a highly satisfactory synchronous motor which could be directly connected to the compressor and which immediately became popular due to the great saving in floor space and consequent saving in building construction made possible by the direct connected unit.

In the October 1 issue, the writer discussed the subject of ammonia compressors, but without specific reference to any particular method of driving them. In this article, an effort is made to supply the operating engineer with certain information which will assist him in a more complete understanding of the motor driven compressor.

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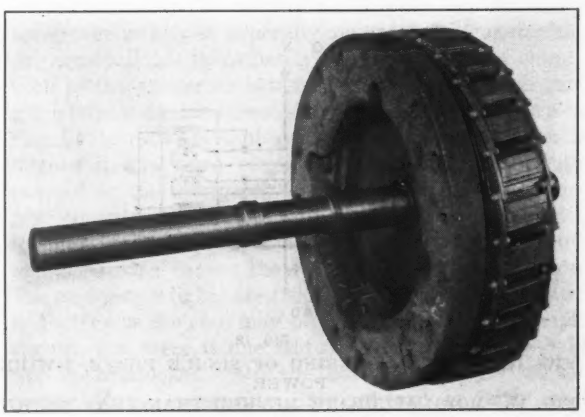


FIG. 1. ROTOR FOR SYNCHRONOUS MOTOR WITH BALLAST RING AND DAMPER WINDINGS

MOTOR SPEEDS

Synchronous motors, as applied to ammonia compressor drives, are frequently designated as slow speed, medium speed and high speed. In the case of the belt driven compressor, the high-speed synchronous motor is used and generally the exciter for furnishing d.c. excitation current to the motor is directly connected to the motor shaft.

Medium speed and high-speed motors are generally used for direct connection to compressors where the ice making capacity is 25 t. per day, and upward. It will often depend upon the individual likes and dislikes of the owner as to whether he will use a medium or high-speed compressor. One of the advantages of the low-

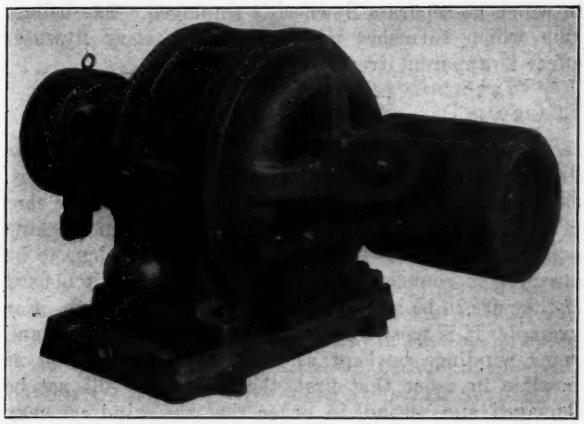


FIG. 2. SYNCHRONOUS MOTOR ADAPTED FOR BELT DRIVE TO AMMONIA COMPRESSORS

speed motor is that its design is such as to permit of its being thrown directly across the line.

In the case of the medium and high-speed motors, some method of reduced voltage starting is required. In either case, however, the question of starting synchronous motors need not give the operator any concern since the starting equipment furnished with synchronous motors has been so well developed and so simplified as to reduce the starting of such motors to a single operation, that of pushing a button.

Acceleration of the motor and compressor, the application of the excitation current to the motor fields at the proper moment and other operations are, in the present day design of synchronous motors, entirely automatic.

What Is a Synchronous Motor?

Often the question is raised, in what manner or degree does a synchronous motor differ from a slip ring, or a squirrel cage induction motor? As a matter of fact, there is not a vast difference in the actual construction of induction and synchronous motors since each type must have a frame, a stator, a rotor and a shaft, together with suitable means of connecting the motor to the supply current through some control apparatus for starting and stopping.

A synchronous motor, however, has certain features of design and construction not common to the induction motor. For example, the rotor in addition to its laminated poles which are secured to the spider, is also provided with a squirrel cage winding, sometimes referred to as amortisseur winding, the function of which is to permit the motor to be started and accelerated to approximately 98 per cent of running or synchronous speed during which time the motor is operating as an induction motor. At approximately 95 to 98 per cent of synchronous speed, the rotor fields are automatically connected to the excitation or direct current supply, whereupon the rotor pulls into synchronism or synchronous speed.

It is evident, therefore, that the operating speed of any synchronous motor is closely related to the frequency of the current supplied to same. The other factor which is closely related to synchronous speed is that of the number of poles built into the motor.

The formula is expressed thus:

$$\frac{\text{Cycles per second} \times 60}{\text{Pairs of poles}} = \text{Synchronous Speed.}$$

Example: A motor having 40 poles (20 pairs) is supplied with current at a frequency of 60 cycles per second. What will be its speed in revolutions per minute?

$$60 \times 60 = 3600 \div 20 = 180 \text{ r.p.m.}$$

$$\text{Conversely, } \frac{\text{Cycles per second} \times 60}{\text{Synchronous speed}} = \text{Pairs of poles.}$$

Since the speed of synchronous motors is not influenced by voltage or load variations, such motors are particularly desirable for ammonia compressor drive because the maximum output of a given compressor, operating under any given condition of pressures, volumetric efficiency, etc., will depend upon constant speed.

Generally, synchronous motors used for driving ammonia compressors, whether belted or direct connected to the machine, are designed to operate at unity power factor when supplied with normal field excitation.

A motor designed for unity power factor is most efficient at that power factor, therefore, if motor maximum efficiency is desired, normal field excitation is necessary. This at once raises the question, what indicating instruments should be provided on the starting panels for indicating just what is taking place and what a motor is doing.

Obviously, it is possible to operate with but few instruments if one is not interested in economic results; however, money spent for a complete complement of instruments is money well invested. For example, an a.c. ammeter and an a.c. voltmeter will indicate the voltage applied to the motor and the amperes flowing

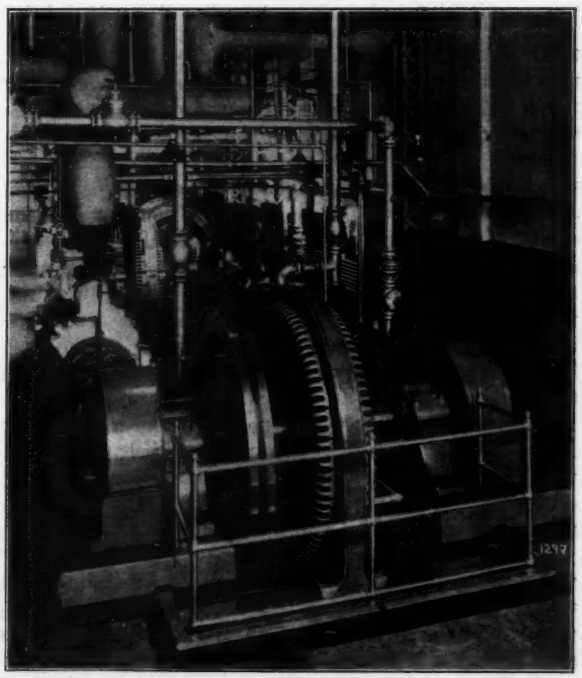


FIG. 3. SYNCHRONOUS MOTORS DRIVING AMMONIA COMPRESSORS

in the motor circuit. Also a d.c. voltmeter and a d.c. ammeter will indicate exciter performance within certain limits, which is desirable since correct excitation voltage and amperage are necessary to motor efficiency.

A power factor indicator is likewise important since the operator can plainly see what excitation is required to be applied to maintain the power factor at any desired value, which, for compressor drive is, as previously stated, generally unity.

In Fig. 1 is shown the rotor of a 50-hp. synchronous motor. This illustration clearly indicates the position and construction of the amortisseur or damper windings which are provided in order that the motor may be started in the same manner as the ordinary induction motor.

This figure also shows the heavy ballast ring which is used to provide the required flywheel effect.

The rotor fields of synchronous motors may be supplied with excitation current from a d.c. machine belted

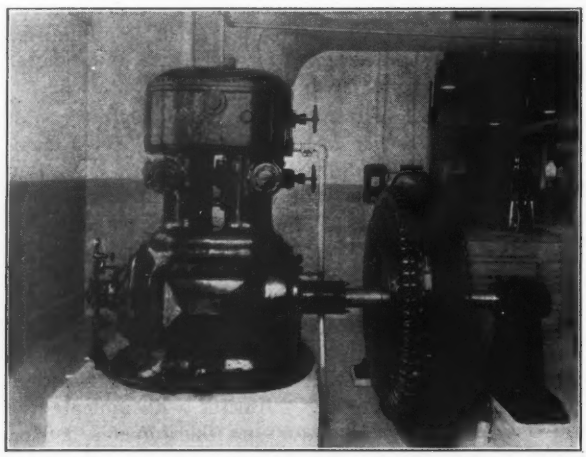


FIG. 4. SYNCHRONOUS MOTOR DRIVEN COMPRESSOR UNIT

to the shaft or direct connected to the shaft or from a motor driven exciter set. In most ice and refrigerating plants where the motor is directly connected to the compressor shaft, the independent motor generator set is used. This makes an exceedingly satisfactory arrangement since the motor generator set may be started simultaneously with the synchronous motor by reason of the fact that the starting circuit of the motor generator set is connected to the starting push button of the synchronous motor. Such starting is usually accomplished by means of an automatic magnetic across-the-line starting switch arranged for connection to the push button control of the motor which may be located on the starting panel or at some other convenient location.

In Fig. 2 is shown a type of synchronous motor frequently used where the compressor is belt driven. It will be noted that the direct current exciter is directly connected to the motor shaft. This makes a very compact arrangement and eliminates belts.

In Fig. 3 is shown a duplex ammonia compressor with the motor directly connected. It will be noted that in this particular installation not all of the flywheel effect is concentrated in the rotor but part is supplied by a separate flywheel.

In Fig. 4 is shown a direct connected synchronous motor and vertical enclosed type ammonia compressor in which no separate flywheel is employed. The ballast ring which furnishes most of the necessary flywheel effect is apparent from the illustration.

Care and Operation of Motor Driven Compressors

Insofar as the care and management of the motor driven compressor are concerned, the same suggestions, as referred to in the October 1 issue, relative to the care of the compressor apply to the electric driven machine equally as well; however, there are certain things to be observed in connection with the motor and switchboard if they are to be maintained in the best condition. For example, it is most important that both the stator and rotor windings be kept as free from dirt and oil as possible in order that first, the insulation will not be damaged and second, in order that the windings may receive proper ventilation.

It is also important that the journal bearings be kept properly adjusted in order that the rotor will always be central in the stator. It is, of course, important that the entire machine be well grounded, particularly in the case of high voltage motors. Failure to maintain proper motor grounds might at some time easily result in serious personal injury to the operating crews.

With reference to the starting equipment, this does not call for any unusual treatment except that all such apparatus must be kept clean and in working order and the oil in the oil circuit breaking switches changed sufficiently often to insure that the dielectric strength and other requisite properties are maintained.

Sulphur in coal is present in several different ways. A considerable part is present combined with the carbon and hydrogen and this organic form is often called volatile sulphur because it is driven off with the volatile matter upon heating. Its presence causes a loss equal to the difference between the heating value of sulphur and carbon and sometimes an additional loss due to corrosion.

A small percentage of sulphur is combined with calcium in the gypsum formation. This does not change with heating and has little practical significance. The most important sulphur compound is the pyrite form in combination with iron. This is sometimes in small particles more or less uniformly distributed through the coal and sometimes in coarse flakes, lumps and veins.

The total sulphur content as well as the form in which it is present varies considerably with the coal one particular sample of Pennsylvania coal with a little less than three per cent total showed on analysis about 2 per cent pyrite, 0.7 per cent organic and 0.01 per cent sulphate sulphur.

Because of the difference in specific gravity, a considerable portion of the pyrite can be removed if it occurs in the flake or lump form. Central Pennsylvania coals have a large percentage of coarse pyrite and are well adapted to cleaning or washing.

Central States Electric Co. has announced plans for installation of a new 5000-kw. turbine at its Iowa Fall, Iowa plant next spring at cost of $250,000, coincident with the completion of its new boiler plant unit, costing $150,000.

Air Compressor Capacity Regulation

ANALYSIS OF DIFFERENT TYPES AND METHODS OF CAPACITY CONTROL. ENUMERATION OF THE ADVANTAGES OF EACH. BY E. ROWLAND

CAPACITY REGULATION of an air compressor is ideal if the compressor is operated at precisely the speed that will deliver the amount of air required at the instant. This is done in the case of steam driven compressors but is obviously impossible in the case of electric motor driven compressors which, because of inherent characteristics of the driving motor, operate at constant speeds.

THROTTLING UNLOADER CONTROL

Various means are employed to vary the output of constant speed compressors among which, those in common use, are illustrated in Fig. 1. The throttling unloader is a device consisting of a partially balanced valve which is placed in the intake of the compressor for the purpose of shutting off completely the intake air when the air pressure in the receiver is up to the desired maximum and opening up the tanks when the pressure has reduced a desired amount. The cut off valve, normally held open by a spring, is operated by an air tight piston under the control of a pilot valve which opens at a designated pressure to admit air to the piston and thus to close the intake valve. The compressor then operates as a vacuum pump exhausting the air in the cylinder against the receiver pressure until the number of compressions becomes so great that no more air is exhausted and the piston moves back and forth in a partial vacuum. When the air pressure in the receiver has been reduced a predetermined amount, the pilot valve closes and the air behind the unloader piston escapes through a small hole in the piston and allows the intake valve to open.

Advantages of this system are simplicity and cheapness. The primary disadvantage is excessively high temperatures developed due to the extremely high compression ratio occasioned by exhausting the air from the cylinder against receiver pressure when the intake is closed. Some leakage always occurs past the compressor valves, the piston rod packing and in the intake valve itself. All this air has to be compressed from a partial vacuum to the receiver pressure which is commonly 100 lb. per sq. in. The number of compressions is sometimes so great that spontaneous-combustion temperatures are reached. An excess of lubricating oil or accumulation of carbon on discharge valves may cause an explosion.

DISCHARGE LINE UNLOADERS

Discharge line unloading is always used in conjunction with the throttling unloader as shown in Fig. 1. It consists of a balanced atmospheric valve and a check valve located in the discharge pipe from the compressor. In a two-stage compressor it is located only in the discharge pipe of the high-pressure cylinder. A variation of this is an atmospheric valve located on the high-pressure cylinder and connected to the indicator ports of each end of the cylinder. This avoids the necessity for the check valve since the cylinder discharge valves serve this purpose. The unloader is under the control of the pilot valve which controls the throttling unloader and the atmospheric discharge valve is opened simultaneously with the closure of the intake valve. All air exhausted from the low-pressure cylinder and the inter-

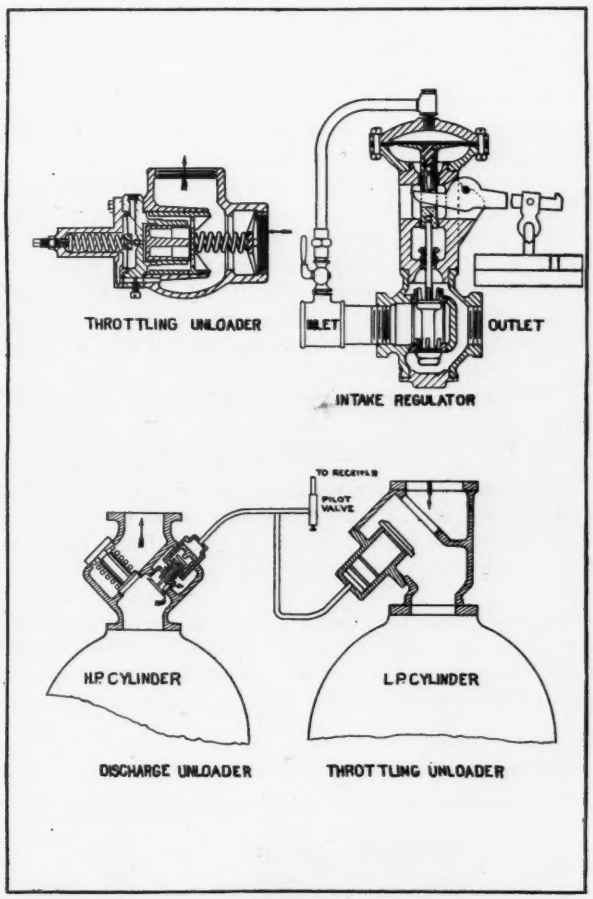


FIG. 1. THROTTLING, INTAKE AND DISCHARGE TYPES OF UNLOADERS

cooler thus passes to the atmosphere instead of to the receiver. This prevents the large number of compressions, therefore increasing the safety of the installation.

Disadvantages of this system lie in the fact that it is not flexible since the compressor must operate at either full capacity or no capacity and no intermediate capacity is afforded. On account of the time required to exhaust the intercooler and the time required to pump it up again, such a capacity control is necessarily not sensitive to air consumption requirements and does not hold a very close range of pressures.

Intake regulation consists usually of a diaphragm-operated balanced valve, which, by controlling the amount of opening of the valve, is able to hold a con-

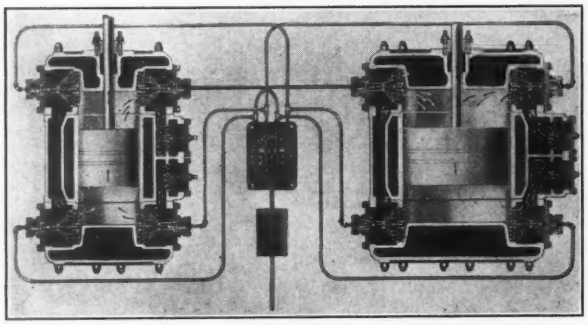


FIG. 2. CLEARANCE-POCKET CONTROL SHOWING ARRANGEMENT FOR FIVE-STEP REGULATION

stant pressure on either the intake side of the compressor or on the discharge side depending upon which is required. If the discharge pressure is to be controlled, the diaphragm is placed under discharge pressure and the valve adjusted accordingly.

Advantages of this regulator apply only to low pressures such as are frequently encountered in compressing gas. For discharge pressures up to 15 or 20 lb. per sq. in., it operates admirably and when the intake pressure is to be regulated, as occasionally occurs, the intake regulator is adaptable. It, of course, suffers all of the disadvantages of the throttling unloader if used to regulate high pressures, since it would tend to increase the number of compressions when throttling the supply of air.

Clearance Pocket Control

Clearance control consists of opening, at predetermined pressures, valves leading into clearance pockets, usually cast as a part of the air cylinder. These pockets are used in both the high and low-pressure cylinders. Opening the valve leading into the pocket causes the compressed air to flow into the space on the compression stroke and less of it to be discharged. Upon the return stroke, this air in the pocket expands behind the piston and returns the work done upon it so that the loss in power is only that occasioned by cooling during the cycle.

It can be easily seen that a series of such pockets can be arranged to give any desired reduction in capacity even to zero capacity. Pockets are generally cast in each end of both the high and low-pressure cylinders of a two-stage compressor and of such size that the capacity of the compressor will be reduced ¼ for each pocket thrown into communication with the cylinder bore. The usual method is to open the valve into the clearance pocket of the high-pressure cylinder simultaneously with that in the low-pressure cylinder. Capacities of full,

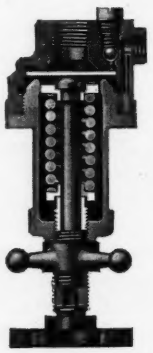


FIG. 4. UNLOADING INLET VALVE

¾, ½, ¼ and no load are the common ranges. All pocket valves are under the control of a regulator designed to operate the various steps with a difference in receiver pressure of from ½ to 3 lb. or a total range from full load to no load of from 2 to 12 lb.

Some compressor builders use the "Free Air Method" in conjunction with the clearance pockets to effect an ingenious method of preventing the clearance pockets from becoming heated due to repeated compression of the same air. This system is also used to avoid the use of clearance pockets at no load, the no load being accomplished by holding all the inlet valves of the low and high-pressure cylinders off their seats and thus per-

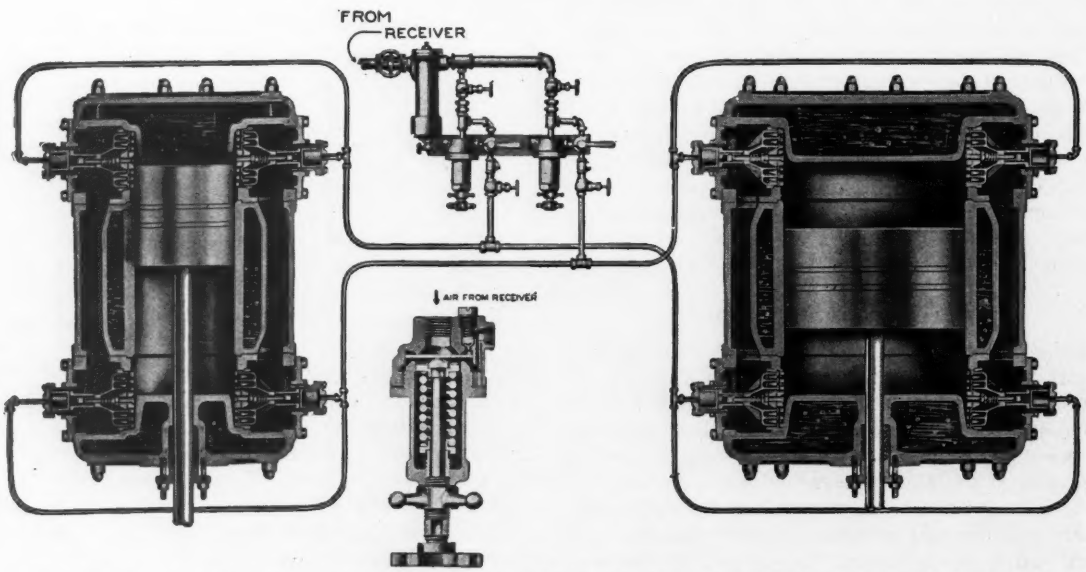


FIG. 3. FREE-AIR CONTROL SHOWING GENERAL ARRANGEMENT OF THREE-STEP-CAPACITY REGULATION

mitting the air drawn into the cylinder to return through the inlet valves without being compressed.

Free Air Control

Almost all reciprocating compressors employ plate valves of some form or other. In the free air method these plate inlet valves are equipped with a lifter fork which bears on the plates and forces them off their seats when air pressure is admitted to pistons or diaphragms are arranged to operate these lifter forks. These unloading valves are placed under the control of a regulator or one or more pilot valves which open or close the valves according to the demand for air as indicated by changes of pressure. Full opening of all valves is obtained and air flows freely into the cylinder through the inlet valves on the suction stroke and back through the same valves on the return stroke. No work is done on the air. It is obvious that with this arrangement all the inlet valves in one end of a cylinder must be held open so that no air will be compressed in that end and,

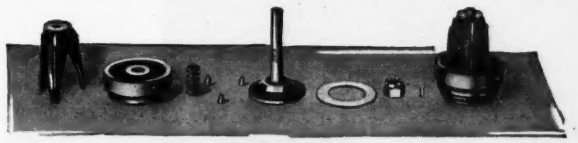


FIG. 5. SIMPLATE UNLOADER

as a consequence, capacities of full, half and no load are obtainable. Some compressors are equipped with more than one low-pressure cylinder, consequently, capacities in quarter steps are afforded.

Advantages of the free air method are adaptability to any kind of control, sensitive capacity control, absence from heating due to compressing the same air over and over and universal application. The method is applicable to single cylinder, duplex, multi-stage and multi cylinder compressors. The method is in general use on high speed portable compressors and has come into general use on large capacity single and two-stage compressors.

In Fig. 2 is shown a combination of this control with the clearance pocket control which eliminates the heating of air in the pockets and eliminates the use of pockets for no load, further cooling the compressor cylinder during the unloaded period. During operation at any partial load, fresh, cool air passes through the check valve thence through the pocket past the unloading valve into the cylinder. At no load, all the unloading inlet valves are held open. In this system, little if any air is recompressed and very cool operation results.

A New Power Torsionmeter

By Dr. Carl Commentz

IN THE LAST YEAR, there has been developed a new apparatus, by which it is possible to measure the torsion of shafts under load with an accuracy and simplicity heretofore unknown. The principle upon which it works is the measurement of the elongation of a steel string stretched out tangentially to the shaft and fixed to it by two brackets which are in their turn fixed to two wrought iron rings placed upon the shaft. By the one it may be set to vibration and the other is influenced by the string so that it generates an alternating current. If the length of the string is changed by increasing the torsional momentum of the shaft, the frequency of the alternating current is varied correspondingly. The current actuates a loud speaker provided at some remote place in an observation station.

In this station, a second similar system is provided but there the string is stretched manually by a micrometer screw and its length and load can be accurately ascertained. This string also is controlled by an electromagnet and by a loud speaker. Its meter is divided into 400 deg. of different sound pitch.

Now if, for instance, the string of the shafting, which is to be measured, is stretched to 100 deg. when the shaft is under no load, the loud speaker emits a certain sound. The control string in the station is adjusted to the very same tension and sound by the micrometer screw. No musical ear is necessary for the human ear.

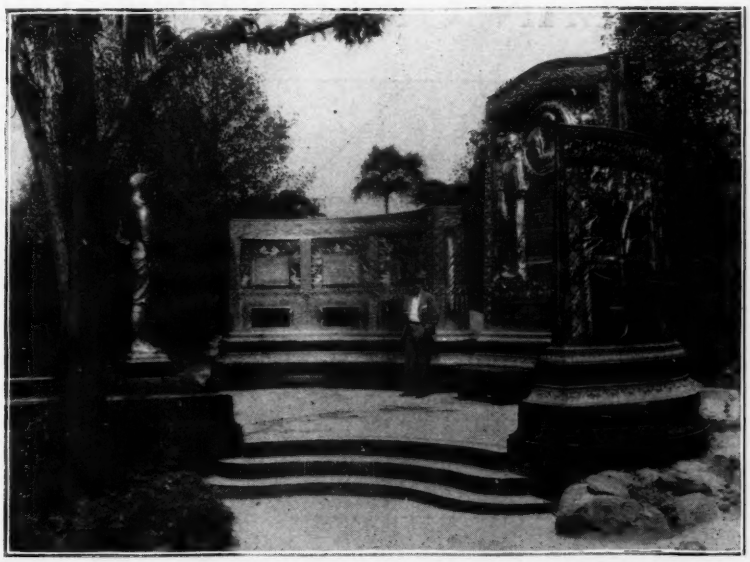
NEW TORSIONMETER FOR MEASUREMENT OF POWER TRANSMITTED BY SHAFTING

If the two do not correspond with absolute accuracy, there is no clear but an irregular sound, varying in intensity. If a load is put on the shafting, the string fixed to it is elongated and its pitch raised. By the control instrument, it may be stated that this raising corresponds to say 210 deg. and this makes it possible to calculate that the load of the shafting amounts to say 21,000 b-hp. if in this case each degree corresponds to 100 b-hp. This was the case at the trials of the North German Lloyd liner "Bremen" the shafts of which had to carry an average load of 22,500 b-hp. The control station was provided in a cable room and the loud speaker could be switched alternately to any of the four lines of shafting within a very short time as the tuning for each shaft required only 15 sec.

This new apparatus has not only the advantage of being very simple and accurate but also of requiring only a very short piece of shaft. On the "Bremen," the rings on the shafting were fixed at a distance of only 42.5 cm., this being equal to about 17 in., while the torsionmeters used heretofore required a much greater length of shafting in order to arrive at an equal accuracy. For small engines, the apparatus has been designed by Messrs. K. Maihak of Hamburg, so that power variations as low as one b-hp. can be ascertained by a change of one degree in the reading of the extension of the control string.

THE WESTINGHOUSE MEMORIAL

A Notable Contribution to American Art



IN THE memorial to George Westinghouse, founder of the Westinghouse industries, which was unveiled at Schenley Park, Pittsburgh, on October 6, American art has received a notable contribution. Casting aside all classical allegorical and conventional precedents, the creators of this monument have produced an unique work, thoroughly modern in character, typically American in spirit and wonderfully successful in conveying to the spectator a feeling of veneration for the genius whom it commemorates.

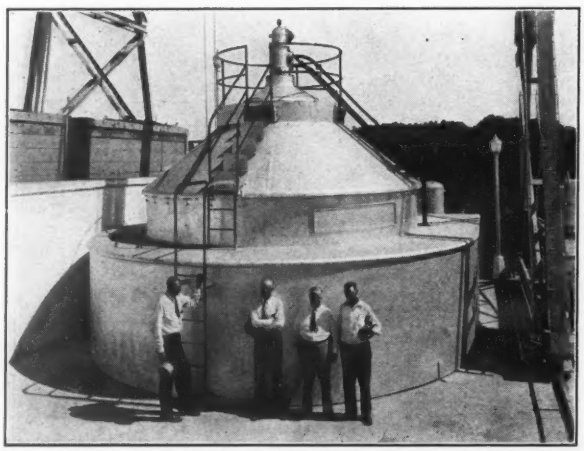
This monument, erected by the Westinghouse Memorial Association composed of 54,251 members mostly employes, consists of a central panel carring a medallion of George Westinghouse, flanked by two semicircular wings, each of which is divided into three panels. On each panel is depicted in low relief one of Mr. Westinghouse's achievements. This central panel and its supporting wings are in themselves beautiful but the creative genius of the artist has added another detail which transforms the whole work from a dead, into a living figure—the figure of the American youth. Standing well back from the panels and facing it in a natural position, he represents this generation inspired by the accomplishments of the master.

Daniel Chester French modeled this youth as well as the central panel of the memorial and though this 80-yr.-old sculptor has achieved world-wide fame for his Lincoln Memorial statue and others, it is believed by many critics that this latest product of his genius must be placed among the foremost of his works.

The monument itself stands upon a base of Norwegian granite, a jet black stone with embedded crystals of felspar. The panels and the youth are of gold-leafed bronze, the panels having Norwegian granite insets. The work was designed by Henry F. Hornbostel and Eric Fisher Wood, while the panels depicting the Westinghouse achievements were executed by Paul Fjelde.

Not the least important part of this memorial is its setting, by a lily pond, in a wooded glen overhung with weeping willows. A stream has cut a valley through a steep hillside, and in this valley where it is hidden until one is almost upon it the memorial has been placed. It is a work of art in every sense of the word.

KAPLAN UNIT *Drives Outdoor Generator at* Merced Falls



UNUSUAL PLANT OF SAN JOAQUIN LIGHT & POWER CORP. IN CALIFORNIA PROVIDES 4000 KV-A., FROM UNIT CONTROLLED BY POND LEVEL AND FLOW. BY HAROLD K. FOX*

♦♦♦

SEVEN-FOLD INCREASE in output from the same river flow was the result obtained recently by engineers of the San Joaquin Light and Power Corp. in rebuilding the old Merced Falls hydroelectric plant on the Merced River, California. The installation which has just been put into operation here on the site of one of the oldest water power developments in the State, represents one of the most modern advances in the science of hydroelectric generation. Though it has some precedent in other parts of the country, it is the first outdoor generating plant to be installed on the Pacific Coast. It is combined with a substation, the whole development being designed for semi-automatic control, requiring but one operator.

The Merced Falls power house varies from the characteristic California plant also in operating at slow speed, under a low head. Situated far down on the river, the plant has several unusual water conditions to meet. Seven miles upstream is an irrigation storage reservoir and two miles below the plant are the canal intakes. Necessarily the stream flow is closely regulated and the release from storage uniform, since the slightest fluctuations cause trouble in the distribution canals. In designing the power house, therefore, it was decided not to carry peaks with the plant, which is relatively small on the system but instead to maintain a constant flow and pond level.

In connection with the rebuilding of the power house, the level of the pond above the plant was raised 6 ft., bringing the operating head to 27 ft. Because the pond is used for log storage, and to protect valuable adjoining property, ample and reliable spillway capacity had to be provided in the crest gates on the dam to prevent damage during flood periods.

Stream flow here is widely variable, from only 100 c.f.s. in winter, when storage in the irrigation reservoir is taking place, to a possible 2200 c.f.s. in summer, when water is being released; there are also periods of flood flow. To meet the requirements of this variation and to procure maximum efficiency under the low operating head of the plant, a Kaplan turbine was chosen for installation. The propeller type wheel is admirably adapted to low heads and the angle of the blades can be

*Construction Engineer, San Joaquin Light & Power Corp.

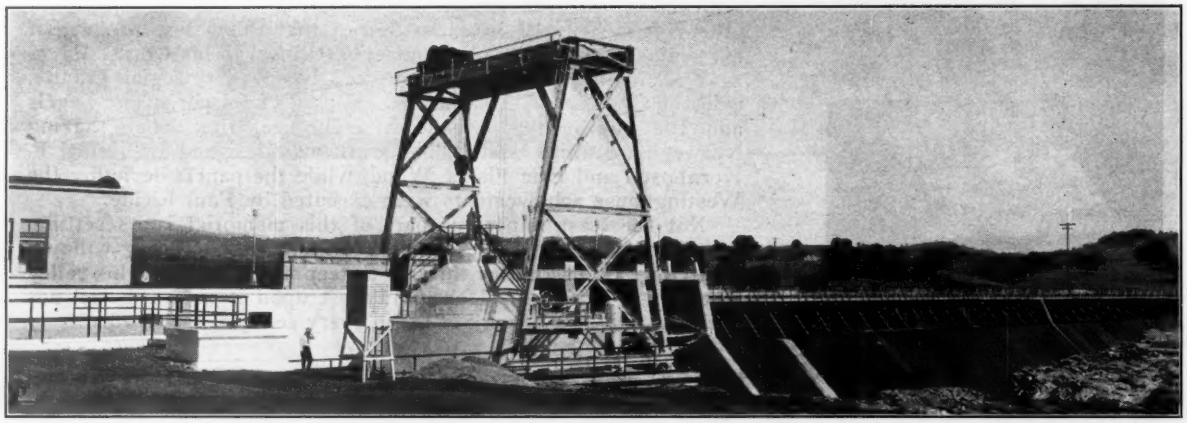


FIG. 1. VIEW OF MERCED FALLS HYDROELECTRIC PLANT SHOWING RECONSTRUCTED DAM

automatically adjusted to meet variations in flow and head and thereby maintain an approximately constant efficiency.

No governor is installed on the unit, but it operates instead under a float control which automatically and simultaneously adjusts the turbine wicket gates and the angle of the turbine blades to changes in stream flow, the head remaining constant. Tests on the unit have proved that the control system and the turbine respond instantly to slight changes in the pond level.

Principal characteristics of the wheel are as follows: net head, 27 ft.; maximum discharge, 2200 c.f.s., 5220 b.hp.; 128.6 r.p.m.; efficiency at 75 per cent load, 88.3 per cent. The wheel was purchased from the S. Morgan Smith Co.

Several factors led to the building of an outdoor plant here, favorable climatic conditions of this region and a possible saving of $12,000 in the project being the most important.

No special problems were presented by the generator and a standard type was purchased from the Westinghouse Electric & Manufacturing Co. Like all recent slow speed units, it is built up of welded structural steel. A Kingsbury thrust bearing carries the rotor. The characteristics of the generator are: 4000 kv-a.; 86 per cent power factor; 3440 kw.; 3-phase, 60-cycle, 12,500-v.; 128.6 r.p.m.; efficiency at 100 per cent power factor and ¾ load, 96 per cent. The field is energized from a motor-driven exciter located in the control building.

The generator and housing are supported on a huge concrete foundation block, out of which is formed the scroll case of the water wheel and the draft tube leading from it.

Control boards for the generator, substation, batteries, motor-generator set, air compressor and exciter, are housed in a small building near the unit. In one end of this building there are bachelor quarters for a relief operator.

Automatic controls make this plant almost self-operating. The unit is started by hand but is automatically shut down by a relay which protects it against heating of Kingsbury bearing oil, under- or over-excitation, hot bearings on exciter, turbine, or generator; overspeed, overload on generator, internal short circuit

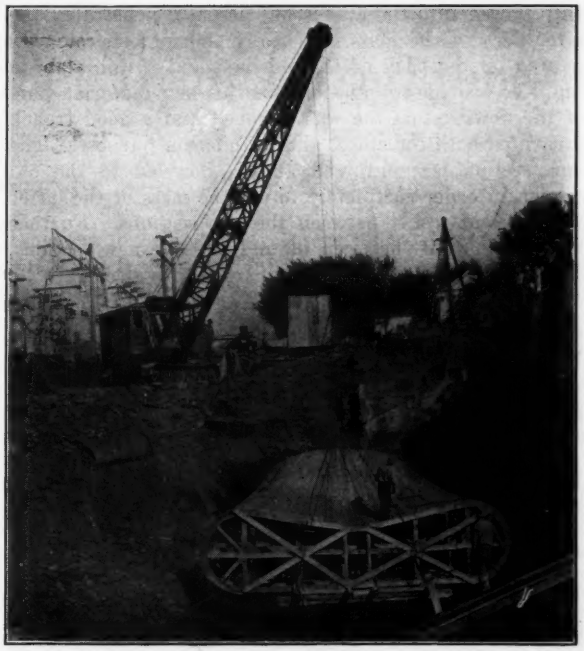


FIG. 2. LOWERING THE DRAFT TUBE FORM INTO PLACE

or ground in generator, and high temperature in generator field. There is also a separate float in the pond which operates a gong indicating high or low water, in case of failure of the automatic operation of the turbine gates or crest gates on the dam or their lack of capacity to handle any sudden increase in flow.

A 30-t. gantry crane was substituted for the usual power house type and has proved satisfactory. It is so located that it can be used to operate the intake gates. The crane has a power lift but the travel of the carriage and of the gantry is by hand.

The original dam at this site was timber crib, but about 20 yr. ago it was rebuilt as a concrete gravity structure. This old dam was sufficient for the low head to which it has been subjected before, but was not considered safe for the increase in head. It was drilled full of holes and grout forced into the old concrete not

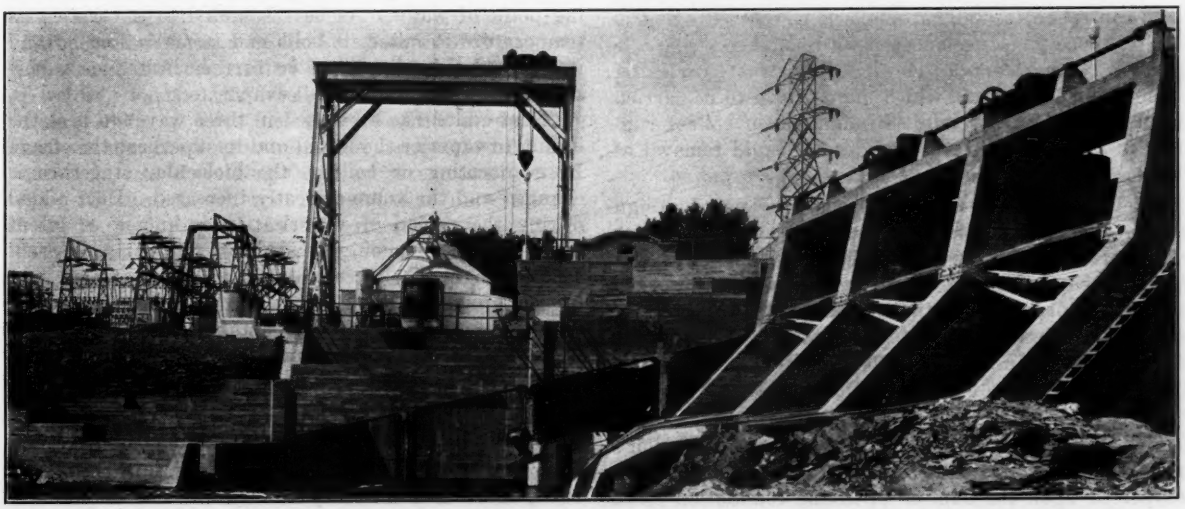


FIG. 3. VIEW OF OUTDOOR UNIT AT MERCED FALLS, SHOWING SUBSTATION, FISH LADDER AND SPILLWAY

only flowed into the cracks but actually penetrated the interstices in the mass. A heavy slab of concrete was poured on the back of the old dam and a thin slab on top. To provide foundations for this new material, part of the downstream toe was removed and a good trench excavated both for cutoff and foundation purposes. The new section is reënforced and is doweled to the old section in order completely to use the mass of the latter and prevent uplift between the two sections. Further to prevent uplift between the old and the new sections, an elaborate system of tile drains was provided.

The maximum recorded flow of the river is 35,000 sec.-ft., therefore it was decided advisable to provide for the maximum possible, which is 60,000 sec.-ft. As stated before, the purpose is to maintain the pond at practically a constant elevation, namely, 344 ft. above sea level, to obtain the maximum output and also to

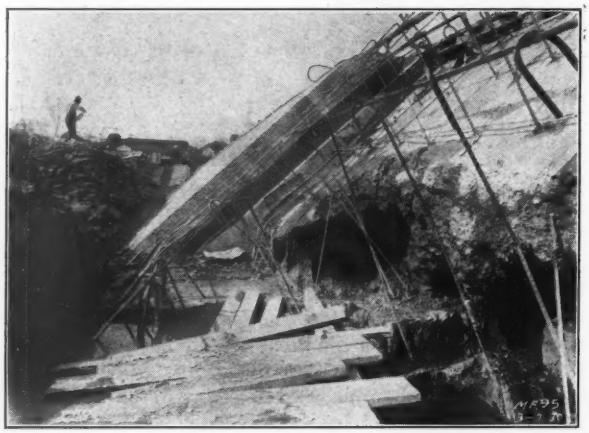


FIG. 4. NATURE OF FOUNDATIONS AND METHOD OF JOINING NEW CONCRETE TO OLD ON DAM

prevent a rise above elevation 344 on account of adjacent property. This is accomplished by a sequence of operations as follows:

The water wheel will automatically handle all flow below 2200 sec. ft. The next 3300 sec. ft. additional are to be handled by an automatically-operated tainter gate and the next 6600 additional by two motor-operated, hand-controlled tainter gates, the balance of the 60,000 sec. ft. capacity being obtained by removing the needle beams. These beams can be removed by merely jacking them up off their seats, which allows them to be carried down stream. A special jack mounted on rollers running in an enclosed track provides for rapid removal of the needles by one man.

The intake gates were a serious problem of design as the two openings into the scroll case of the water wheel are 16 ft. square. The cost of steel gates was found to be prohibitive, therefore a design was worked out, using primarily a timber gate with a heavy reenforced concrete cap on top of it, which served the same purpose as a timber member and at the same time gave sufficient weight to sink the gates into place.

The Fish and Game Commission requested a fish ladder and one was built according to the Commission's own design. It was constructed of concrete and where supported upon the dam or upon the foundation block of the plant, it was insulated by timber to prevent vibration from frightening the fish. No salmon have seen fit to climb this ladder so far.

The output of this plant, in an average year, will be approximately 15,000,000 kw-hr., and the daily and monthly output are such as to economically fit the system demand. For the next few years, the plant will be operated with a maximum of 1600 to 1700 sec. ft. of water, increasing to 2200 sec. ft. as the release from Exchequer Dam, the irrigation storage structure above the plant, is increased.

Reconstruction on Merced Falls power house was started on October 15, 1929, and the unit put on the line July 21, 1930. The project was designed and built by the Construction Department of the San Joaquin Light and Power Corp., Harold K. Fox, construction engineer, J. W. Jourdan, designing engineer, C. P. Rhine, assistant designing and resident engineer and J. D. McDougald, superintendent.

Characteristics of Steam

STEAM CAN EXIST in one of two forms commonly known to the engineers as saturated and superheated. As long as water is present the steam is saturated. If water particles are suspended in it, it is wet and saturated but if this water is all removed without raising the temperature, it is dry and saturated. Further heating this dry and saturated steam without adding water superheats it.

Wet steam includes an infinite number of conditions ranging from practically pure water and no steam to all steam and no water. As long as water remains in contact with it, the temperature of the steam remains constant as heat is added, this temperature bearing a definite relation to the pressure. When the water is removed or all evaporated, the addition of further heat raises its temperature or superheats it. Steam is dry under only one condition, 100 per cent steam and at the saturation point corresponding to the pressure. As a matter of fact, this condition is practically impossible to attain and commercial steam as it comes from the boiler either has from 1 to 10 per cent moisture or is superheated.

In the steam tables, heat quantities are calculated above an arbitrarily chosen level of 32 deg. F., the freezing point of water. As heat is added to the water, its temperature is raised, it boils and steam is formed and if confined this steam can be further heated or superheated after the water is all evaporated.

Heat added has been used in three ways: to heat the liquid, to vaporize the liquid and to superheat the steam. In evaporating or boiling, the molecular structure is changed and the volume greatly increased. Heat added during the period of vaporization is known as latent heat, which is commonly divided into two parts; internal and external. The internal latent heat is that part used in changing or tearing apart the molecules to change from the liquid to the gaseous state, while the external latent heat is that done in increasing the volume against the existing pressure.

NICKEL STEEL containing about 5 per cent nickel has been widely used for turbine blading but because it rusts, there is a tendency toward the use of stainless steels which are usually alloys of steel and chromium.

Outlook for Welded Boiler Drums Brightens

DEVELOPMENT OF AN ARC WELDING PROCESS AND ADEQUATE TESTING METHODS BY THE BABCOCK & WILCOX CO. AROUSES HOPES OF WELDING ENTHUSIASTS FOR EARLY ACTION ON TENTATIVE AMENDMENTS TO A.S.M.E. BOILER CODE

ANOTHER and perhaps the most important step yet taken toward recognition of welding as a serious and immediate competitor of riveting and forging in boiler drum construction was announced recently by the Babcock & Wilcox Co. after a pressure vessel welding demonstration at its Barberton, O., works.

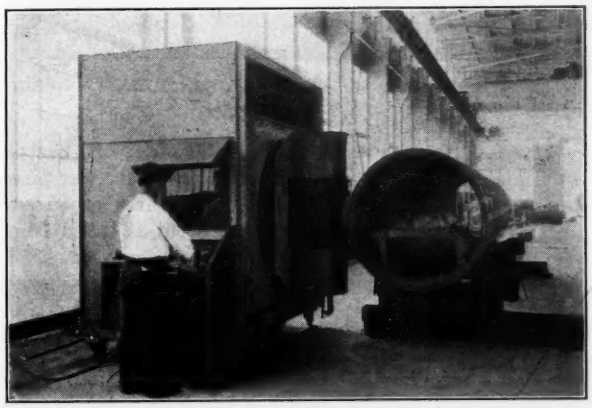


FIG. 1. AN X-RAY MACHINE PERMITS ROUTINE INSPECTION OF LONGITUDINAL AND CIRCUMFERENTIAL SEAMS

Although the welding demonstrations, followed by tests showing that the welds were equal to or superior to the plate metal itself in tensile strength, shock resistance, ductility and ability to withstand repeated tests, were impressive, the ability of properly welded joints, either of the arc or acetylene type, to withstand severe service and high pressure has been well demonstrated over a considerable period in chemical and oil refinery service, so that to the power plant engineer and operator the technical details of the welding process itself are of interest secondary to the practical methods of testing and exploring the finished seam.

Faith of the engineer in the strength of a properly made weld is demonstrated by the extensive use made of welding today. The human element, the possibilities of slag, voids of flaws and the difficulties of detecting them without destructive tests has, however, so far prevented the use of welding for boiler drum construction, where its value is self-evident because of the difficulty, if not impossibility, of making riveted joints the thick plate demanded by high pressures, the danger of caustic embrittlement being enhanced by riveted seams and the high cost of forged drums.

The Babcock & Wilcox fusion welding is an automatic arc welding process developed by the company after a great deal of research. Fundamentally, the machine is a modification of the regular motor-driven element which moves parallel to the weld and which feeds automatically the welding rod in which the electrode itself forms the one pole and the plate to be welded the other. Current flows down the rod, an arc is drawn by the operator and this arc melts and deposits the weld metal which is built up by successive layers to the desired thickness. The simplicity of the machine operation as modified does away with the necessity for great skill on the part of the operator and it is said that any man of average intelligence can produce sound welds by this technique after a few days' practice. In fact, welds made by a visitor after a few minutes instruction and tested later in the laboratory showed a tensile strength almost, but not quite, equal to that of the original plate. This is not proof that the machine is suitable for operation by an inexperienced operator but it does indicate the extent to which the effect of the human element has been eliminated and positive control of the welding operation obtained.

Not content with the positive automatic control of

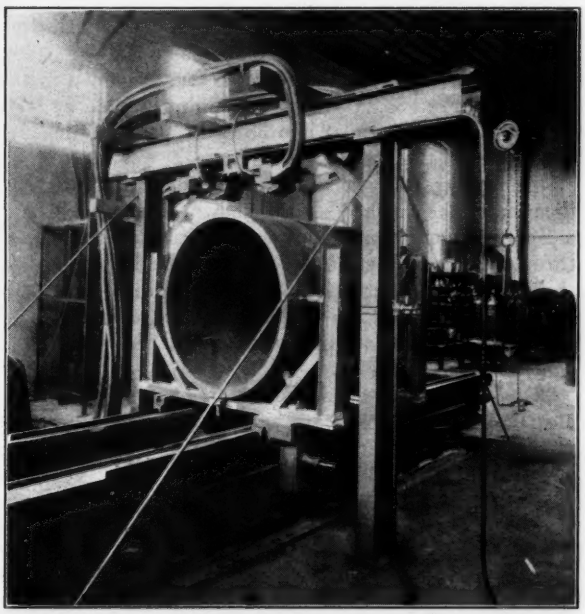


FIG. 2. A SPERRY TESTING MACHINE ALSO USED FOR TESTING

the welding process to eliminate the human element, the company has installed the X-ray machine shown in Fig. 1. This is the first machine set up for X-ray examination of welded drums on a production basis and permits the routine inspection of both longitudinal and circumferential seams. Figure 3 is included to show typical examples of X-ray photographs; at A-A the slightly lighter slip at the left indicates the appearance of a perfect weld; at B-B the white spots indicate voids or slag spots which place the welds just on the border line between good and bad; while at C-C the imperfection of the weld with slag incrustations along the side is evident.

When testing, the welded drum is blocked up as

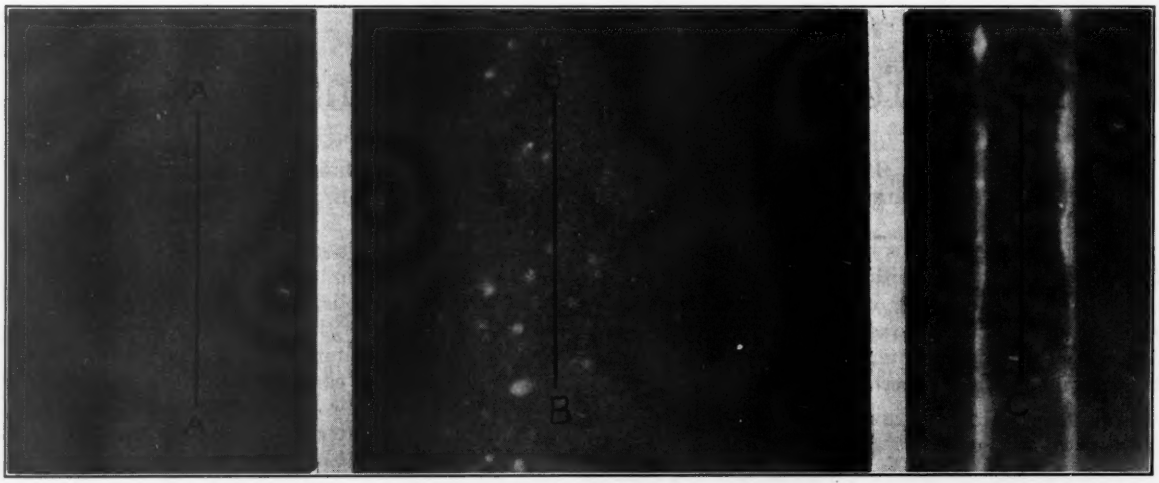


FIG. 3. NEGATIVES FROM THE X-RAY MACHINE SHOW: A-A, A PERFECT WELD; B-B, A QUESTIONABLE WELD, C-C, AN IMPERFECT WELD

shown and the X-ray machine is moved along parallel with the longitudinal axis. Each negative is about a foot long with each setting overlapping the previous one about 50 per cent so that every portion of the weld is photographed twice. Lead tags fastened to the drum by adhesive tape and punched with the carefully-measured distance from a reference mark on the end of the drum, identify the negatives. One of the tags is shown in the center of Fig. 3. Cost of examining welds by this method ranges around 25 to 35 cents per foot depending upon the thickness of the plate.

Another testing machine used to give a qualitative indication of the finished seam is shown in Fig. 2. This is a Sperry machine in which an electric current passed through the weld sets up a magnetic field. Defects in the weld cause fluctuations in the field and these fluctuations are picked up by the machine and amplified by relays to give an indication on a recording strip chart.

One of the most interesting tests, which indicates clearly the high tensile strength of the deposited weld metal is shown by the six test specimens in Fig. 4. These

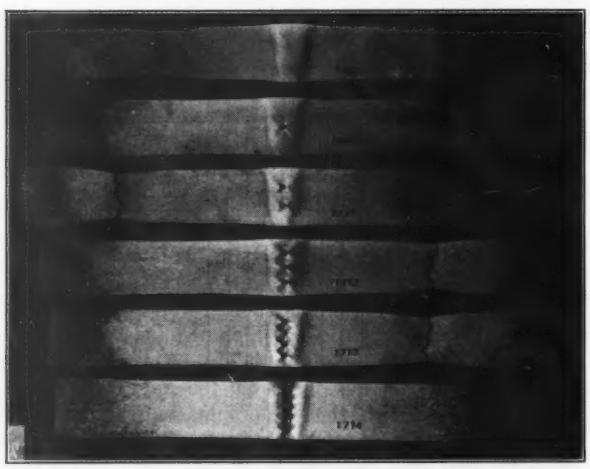


FIG. 4. THAT THE WELD IS MUCH STRONGER THAN THE ORIGINAL PLATE IS SHOWN BY THESE SPECIMENS, WHERE A REDUCTION IN CROSS-SECTIONAL AREA OF 35 PER CENT WAS MADE BEFORE THE WELD FAILED

were taken from a welded sample of A.S.M.E. firebox steel plate and the five ⅛-in. holes made in the test piece represent a reduction in cross-sectional area of 35 per cent. The ultimate strength of the weld as taken from the test piece at the bottom was 74,200 lb. per sq. in. A summary of the characteristics of the welds as reported by the company follow:

TENSILE TEST IN LB. PER SQ. IN.			
Ultimate tensile strength	Min.	Max.	Ave.
B. & W. weld metal	65,000	74,500	67,500
Plate	55,000	65,000	.....
Yield point	Min.	Max.	Ave.
B. & W. weld metal	40,000	55,000	45,000
Plate			½ ultimate

ELONGATION TESTS ON WELD METAL, IN PER CENT			
	Min.	Max.	Ave.
Elongation in 2 in	20.5	38.0	28.0
Reduction in area	32.0	65.0	40.0

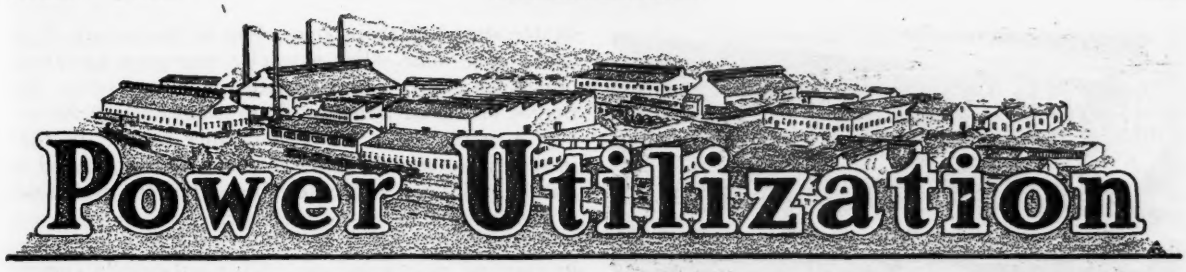
CHARPY IMPACT VALUES	Min	Max.	Ave.
B. & W. weld metal	20	45	28
Plate	19	33	20

SPECIFIC GRAVITY	Min.	Max.	Ave.	% Voids
Plate	7.80	7.85	7.85	0 plus
Bare electrode	7.44	7.68	7.59	3.30
Weld metal	7.83	7.85	7.84	0.12

CHEMICAL ANALYSIS OF WELD METAL, IN PER CENT	
Sulphur	Less than 0.04
Phosphorus	Less than 0.04
Manganese	0.30 to 0.60
Carbon	0.08 to 0.15
Nitrogen	Less than 0.02

In addition, bend tests with the specimen bent to an inside diameter equal to the plate thickness, showed an elongation of the outside fibres ranging from 30 to 65 per cent with an average of 45 per cent. Fatigue tests in rotating beam machines showed an indicated endurance limit of about 30,000 lb. per sq. in. as contrasted to 28,000 lb. for boiler plate steel. One specimen was subjected to 13,697,400 cycles at a calculated stress of 23,000 lb. per sq. in. without failure, while another specimen withstood somewhat over 10,000,000 cycles at a stress of 30,000 lb. per sq. in.

Repeated pressure tests were made on 13 full size drums and shells of various materials. In these tests, water under pressure was alternately admitted and exhausted from the test shell. One welded drum had over 2,000,000 pressure variations at a stress of 16,500 lb. per sq. in. across the welded seam without failure.



Conveyor Selection *for* *Economical Operation*

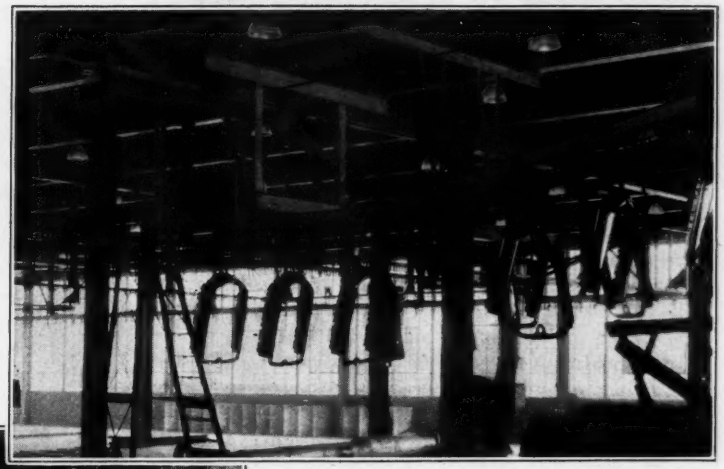


FIG. 1. MONORAIL CONVEYOR FOR AUTOMOBILE RADIATORS

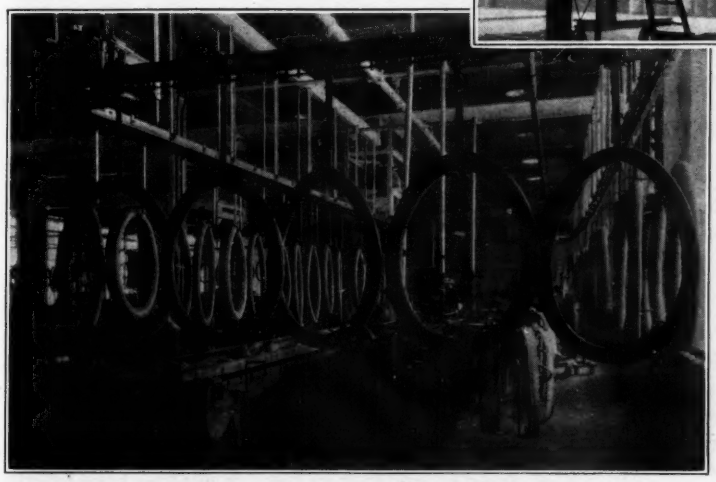


FIG. 3. AUXILIARY CONVEYOR FOR INNER TUBES

By
EDWARD J. TOURNIER

PRESENCE OF A CONVEYOR in the power plant is now no cause for comment, any more than stokers attract special attention. In most cases the boiler house conveyor receives consideration only as a device which transfers coal from one place to another. If it works well, little is thought about it and, if it does not, much is said that is not complimentary. Where handling costs are closely watched, the conveyor shows up in figures which indicate the efficiency of the machine as a unit in the cost of producing power. It is then something more than just a connecting link between two points.

This conception of a conveyor as a part of the production facilities is perhaps infrequent in power plant operation but it is widely accepted in various manufacturing industries. In the latter, the conveyor system may be, not merely a production tool, but it may even be the main stem of the whole process; the entire plant may be built around it. Two notable instances of this are in automobile plants and in the manufacture of automobile frames. In the last named industry, the work is practically all automatically performed on conveyors. The modern foundry is another example of the same principle, although it is less fully automatic than the automobile frame plant.

It will be of particular interest to power engineers to consider industrial conveyors from still another point of view. In addition to being transporters and production tools, conveyors are power transformers and power users. This we think, contains a basis, not only for speculation but also for some constructive thought on the relationship between power and its transformation into commodities.

Whether or not an industrial conveyor is installed under any of the conceptions already outlined, it is necessary to give consideration to the economy in operation of the unit selected. In this instance, economy is intended to include not only the service to production,

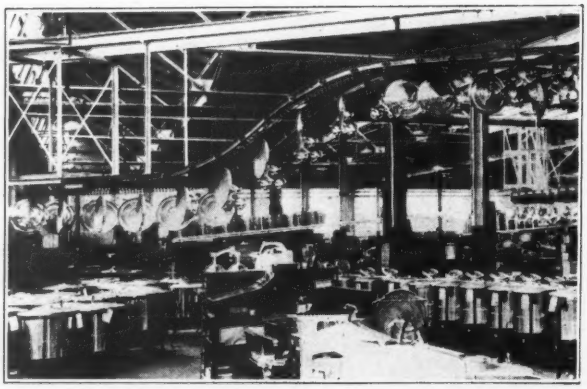


FIG. 2. PARTS ASSEMBLY CONVEYOR FOR WASHING MACHINES

maintenance and repairs, but also the question of power. The principal factors which determine the importance of these various economic relationships are, the type of conveyor, the design of its parts as to accessibility, the frictional resistance of its revolving parts, the power transmission and the means of lubrication.

Industrial conveyors, as has already been suggested, are no longer being considered as just transportation units. They are more properly classed among services to production. This includes assembly conveyors, with their auxiliary feeder lines, and process conveyors. In continuous assembly work, conveyor applications are almost as numerous as the commodities which it is possible to produce in quantity. To mention only a few major uses of assembly conveyors—automobile bodies, frames, wheels and complete cars, are built entirely by the conveyor method. In the same manner, desks, electric irons, instruments, filing cabinets, gas stoves, gasoline pumps, radios and washing machines are being placed on the conveyor assembly line, Fig. 2.

Conveyors for Assembly Work

In any discussion of assembly conveyors, it is useful to bear in mind the nature of this type of equipment. An assembly conveyor is a slow moving conveyor, either of the chain or belt type, which, in the former, may be fitted with special stands or other appliances for supporting some part, to which others are gradually added. The parts to be assembled are brought to the assembly line by feeder conveyors, chutes, elevators or otherwise and are continuously supplied as necessary. Since these conveyors are coupled with an extreme division of the labor of assembling, each operative performing one function of a continuous series, it is essential that the conveyor shall be of a type that is easily kept in operation, with a minimum of shut-downs for repairs. Likewise, the auxiliary units, as Fig. 3, which supply parts to the assembly line must be free from interruptions to service, lest a stoppage of the feeders should disrupt the production schedule.

Roller Chain Assembly Conveyors

From the standpoint of economy in operation, assembly conveyors may be classified in two general groups: chain conveyors and belt conveyors. Auxiliary feeder conveyors are almost always chain conveyors. Chain conveyors for assembly work are usually of the roller type and may be made up of either a single or a double strand of chain, depending on the nature of the work to be done. For example, conveyors for assembling such bulky or heavy articles as filing cabinets, gas-ranges, or similar large units, are usually slat conveyors, Fig. 4, with double strands of roller chain. In these installations, the slats, which may be either wood or metal, are located at the floor line, while the return side of the chain passes below the floor.

Another type of assembly conveyor frequently used in building rear axles, assembling automobile engines, transmissions and the like, consists of two parallel strands of roller chain, traveling on guides which are part of the supporting structure of the conveyor, Fig. 5. In this case, both strands of the chain are above the floor level because the work must be carried on at a height convenient for men working on the parts being assembled. The two parallel chains are connected by special attachments equipped with small turntables which permit turning the work in any desired horizontal position.

Both these conveyors have principles of design which meet the requirements of accessibility, low maintenance and power consumption. The framework is an open, light truss construction with the head and foot shafts easily reached for repair or inspection. The arrangement of the top and bottom chords of the frame which serve as track roller guides is such that the chain is always in view for lubrication and repair. Shaft bearings are equipped with pressure lubrication fittings which facilitate greasing. In addition, the use of steel-bushed-roller chain ensures a low friction factor, thereby conserving power, while the distribution of stresses over large diameter pins in the rollers makes for long wear and low maintenance.

In a single conveyor unit the question of power is usually a matter of minor importance but, in the case of the equipment of an entire plant, the matter is deserving of some attention. In order to illustrate this point, it may be of interest to examine a fundamental power formula for a slat conveyor:

$$P = F\,(S + W)\,LV \div 33{,}000 \qquad \text{Formula I}$$

in which, P = Horsepower at head shaft, S = Weight of top and bottom chains and slats per foot of conveyor centers, W = Weight per foot of material on conveyor; V = Speed of conveyor in feet per minute; L = Length of conveyor in feet, centers; F = Power factor = 0.125.

For a horizontal slat conveyor for assembly, 36 in. wide, 150 ft. centers, to handle desks weighing 300 lb.

FIG. 4. SLAT CONVEYOR FOR SHOW CASE ASSEMBLY

each, spaced 6 ft. apart, at a chain speed of 20 ft. per min.; the chain and slats weigh 40 lb. per foot.

$$P = 0.125\ [40 + (300 \div 6)] \times 150 \times 20 \div 33{,}000 = 1.02 \text{ hp.}$$

to which must be added 20 per cent for transmission losses, making a total of about 1¼ hp. In the event that such a conveyor should be used as the final link in a chain of operations, for example, transferring the desks to the shipping room, the speed would be increased to 50 or 60 ft. per min., with a corresponding increment in power to 3¾ hp. This is frequently done to take care of higher production rates.

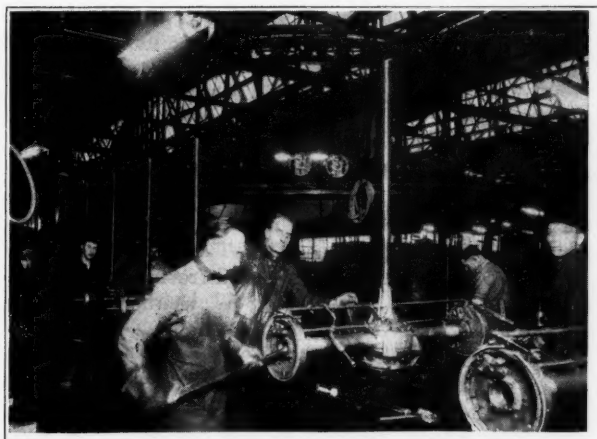
Power for conveyors used in assembling machine parts, if the chains are of the roller type, may be calculated from Formula I, by first transforming the load on each stand, or turntable, into terms of the load per foot of conveyor. This is done by dividing the weight on each stand by the spacing in feet.

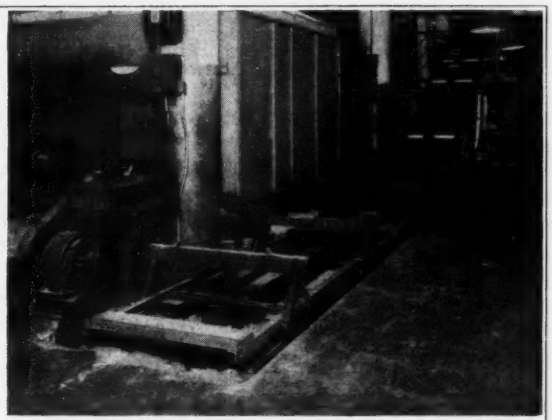
It will be evident from the figures cited here, that the roller type of assembly conveyor is most economical of power, although it is higher in first cost than other designs of equipment.

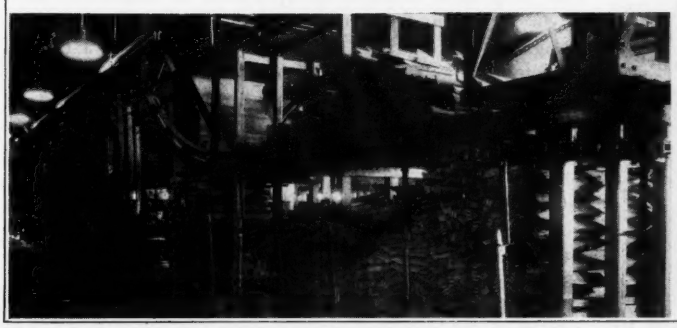
Generally, space limitation is not a bar to the use of the roller chain conveyors but, where such restrictions are operative, a sliding chain, or chain-on-edge conveyor, may be substituted. These conveyors, originally developed for use in automobile body assembly, Fig. 6, are now being applied in numerous other industries.

The chain-on-edge conveyor consists of a single strand of 4-in. pitch, rivetless, drop-forged steel chain, with sprocket terminals at each end. At suitable intervals, the chain is fitted with special hinged attachments designed to push a small carrier truck, on which the parts to be assembled are hauled. The chain is guided by a pair of small steel channels resting on the floor, while a second pair straddle the center line of the chain. The latter form a track for the four-wheeled carrier, one axle of which is engaged by the pusher without lifting action or derailment of the truck. Work to be assembled is placed on the trucks while workmen walk a short distance along the conveyor on the various operations. This is a type of conveyor used in various industries, lately in assembling radio sets. It is inexpensive to install but, on account of friction against the guides, the power required exceeds that for roller chains. The item of maintenance is of minor importance because the chain is of substantial design and, being without pins or rollers, the wear is limited to the edges of the chain. An occasional application of grease is all the lubrication required.

Although the number of commodities which can be assembled on conveyors is great, there is little variation in the path of travel or in the method of using the conveyor. The most economical layout is one in which the assembly line is straight, from raw material to finished product. In auxiliary or feeder conveyors, the case is quite different; they must follow a path which leads to every part of the plant, regardless of location or direc-







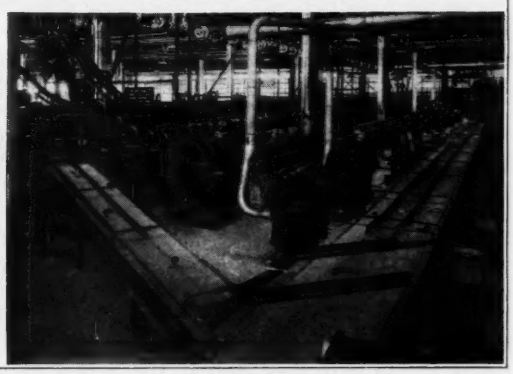


FIG. 5. ROLLER CHAIN FOR REAR AXLE ASSEMBLY. FIG. 6. CHAIN ON EDGE WITH FRAMES FOR AUTOMOBILE BODY ASSEMBLY. TWO STRANDS CLOSE TOGETHER CAUSE FRICTION AT BENDS. FIG. 7. MONOVEYOR, SHOWING BENDS IN TWO PLANES, HANDLING DOOR PARTS. FIG. 8. FLAT BELTS USED FOR BRAKE ASSEMBLY

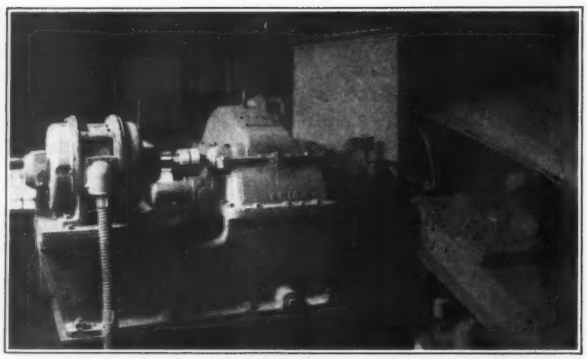


FIG. 9. ENCLOSED TYPE SPEED REDUCER PROVES CONVENIENT FORM OF POWER TRANSMISSION ELEMENT

tion of travel. The feeder must pick up the parts at the source of supply and deliver them to the assembly line, even if this requires going up and down inclines and around corners, all in a single line of chain. These chains are sometimes made in lengths up to 2500 ft. with a single drive. With multiple drives they may be made as much as 5000 ft. in total length.

This type of conveyor, known as a Monoveyor, consists essentially of a continuous overhead I beam track on which are mounted double wheeled trolleys, the latter being connected together by a conveyor chain. The chain transmits only the tensile stresses due to loads suspended from the trolleys. The chain is operated at any desired speed by a driving mechanism which moves the trolleys and their loads continuously around the track of the monorail.

This gives flexibility, Fig. 7, as the rail may be curved at any required angle in the horizontal plane and may turn up or down in the vertical plane. The chain is guided and its path is fixed on the horizontal turns either by means of a sprocket or a series of rollers spaced close together. On the vertical bends the path is determined by the action of the moving trolleys operating on the monorail track. With the proper design of hooks or trays, for attachment to the trolleys, practically any type of load may be carried, and within the strength limits of the individual design, the weight carried by each attachment may be anything from one to 500 lb.

From the point of view of accessibility, the monorail type of conveyor is especially desirable, since the entire working strand of the chain is visible and the terminal shafts and bearings are equally convenient. These are usually located below the ceiling.

Power requirements of the monorail conveyor will vary, as those of any other type, with the load carried, length and speed of the chain. For average conditions, the general formula, (Formula I), will give conservative results, if the power factor F, is made equal to 0.08, on account of the ball bearings in the trolley wheels. In addition to the drive losses to be added to net horsepower, allowance must be made for friction at bends and turns. As an example, for a conveyor 2500 ft. long with 500 hangers, each carrying 100 lb., the chain weight being 10 lb. per foot, the Hp. required for operation at 20 ft. per min. will be:

$$P = 0.08\ [10 + (50{,}000 \div 2500)] \times 2500 \times 20 \div 33{,}000 = 3.6 \text{ hp.}$$

Plus 1 hp. for losses in transmission and bends, a 7½-hp. motor will be ample for this work.

Belt Conveyors

Use of belt conveyors in assembly work is less extensive than of chain conveyors. Belts are best suited to light work such as assembling electrical instruments, radio sets, small cabinet work. Heavy articles with sharp edges and corners soon destroy the belt and interfere with proper operation when passing over the rollers.

Belt conveyors for the services in question, consist of flat belts supported on the carrying side by rollers spaced from 12 to 36 in. apart, Fig. 8, depending on the load to be carried. The return side of the belt is carried on rollers spaced 10 to 15 ft. apart. Pulley terminals at both ends of the conveyor, one being the drive end, and the other the takeup end, are the essential power elements of the conveyor.

Supporting structures of belt conveyors for assembly work are light structural steel frames resting on the floor. They are designed to carry the belt at a height convenient for workmen standing alongside.

Power requirements for flat belt conveyors are lower than for other types because of the lighter weight of the revolving parts and of the belt. The horsepower for a flat belt conveyor may be calculated from Formula I, by substituting for F, 0.06, taking W, as the weight per foot centers, of belt and idlers.

Power Transmission and Lubrication for Conveyors

Although the question of the accessibility of parts is important, power transmission and lubrication are matters of greater concern to operators of industrial conveyors. In the various types of chain conveyors, the design of the chain is such that lubrication is a simple matter, unlikely to interfere with the continuity of operation. In belt conveyors, however, the matter is more serious. Lubrication of the idlers by means of grease cups on plain bearings leads to much loss of time and, in many cases, the presence of a lubricant is objectionable due to the danger of damage to the goods. This condition has led to the use in the idlers of anti-friction bearings which require infrequent lubrication and little attention from the maintenance force.

In practically all assembly or other types of industrial process conveyors, the power transmission elements are of some type of enclosed speed reducer, Fig. 9. Open gear trains are no longer satisfactory, not only because they are unsafe but because of power losses and maintenance. Considered merely from the economic standpoint, it can safely be said that suitable speed reducers save at least 12 per cent of the electric current consumed. In addition, the speed reducer, in conjunction with a variable speed device, permits the control of the conveyor speed to suit the rate of production. This combination makes possible a variation in conveyor speed from 6 to 60 ft. per min., if necessary.

In the selection of industrial conveyors, it is essential to bear in mind that low first cost does not usually go along with low maintenance cost. Also, it is well to remember that speed reducers cost less to operate than open gears. The final test of a conveyor system is the cost per unit of product handled.

IF A DOUBLE-ACTING engine runs over the crosshead, it will exert a downward pressure on the guides during both strokes.

What To Do About Plant Ageing*

GOOD MAINTENANCE, CAREFUL SELECTION AND INTELLIGENT REPLACEMENT KEEP THE JUNK PILE OUTSIDE THE PLANT. BY R. H. ROGERS**

RECENTLY, ONE WRITER tersely stated that every plant has two junk piles, one outside the walls and one inside the walls. The size of the inner junk pile can be kept down by the maintenance men whose primary business it is to keep things from happening and by recommending modernization when needed to hold obsolescence down and insure a reasonably long life for the plant.

Suppose the best procurable equipment is put in today, 100 per cent effective. Depreciation starts immediately, slow or fast according to the diligence of the maintenance forces. To prevent it entirely is impossible. In 10 yr. the condition may be ten below par but, in the meantime, equipment has been improved and a competitor installs it. His equipment may well rate 140 or 50 points better than the 10-yr.-old equipment that is still going strong. Obsolescence has gotten in its work four times as fast as depreciation.

Maintenance men should keep a sharp eye on this phase of plant ageing and make pertinent suggestions on ways and means to keep up perpetual rejuvenation. That is the broad view to take: know what is the best, what trends are, press relentlessly for modernization, install conscientiously and maintain intelligently.

FIND THE WHY OF A SHUT-DOWN

Intelligent maintenance implies that thought be given to the cause of every failure. The unit in trouble must be studied and, if no cause is apparent, the search must extend both ways from the trouble point until the cause is run down and eliminated once for all. Take, for instance, a case of motor trouble. Study of the motor should include its starting duty, peak loads, average heating load, power factor and general behavior. If the motor has the proper characteristics for its work, the examination should narrow down to physical and electrical conditions. If no cause of the trouble is found here, the investigation should be extended to the driven load to determine whether erratic conditions can occur to throw destructive loads on the motor. The power supply and control items should be investigated. Some inexperienced person may be mishandling the equipment. Voltage dips from some remote cause may be the offending item. The control equipment may be unsuitable.

Periodic studies should be made of power equipment because all the time improvements are being made by manufacturers and a type of equipment unsuited to a job 5 yr. ago may be ideal today, while accepted standards of a few years ago may be obsolete now. Any motor or control over 5 yr. old should be coldly scrutinized for present day fitness.

Don't be complacent. Have ideas about improving conditions, put them in writing, in sketches. Many schemes teeming with potential benefits have died in the heads or desks of the schemers because they were pushed too feebly. Some may be too modest to bring their plans to those higher up while others become discouraged at the first belittling comment.

CHANGES WHICH HAVE JUNKED EQUIPMENT

Some trends in electric practice responsible for obsolescence of existing equipment may be summarized to advantage.

Synchronous motors have been so improved, particularly in starting characteristics, that they are now freely applied where but a few years ago induction motors were used. Synchronous motor control has also been improved in many ways among which are the prevention of stalling on undervoltage. Full advantage can now be taken of the power-factor-improving characteristics of synchronous motors together with their inherent adaptability to low speed drives. Substitution of syn-

**Industrial Eng'g Dept., General Electric Co.
*From a paper before the Electrical Maintenance Engineers, Cedar Point, O., 1930.

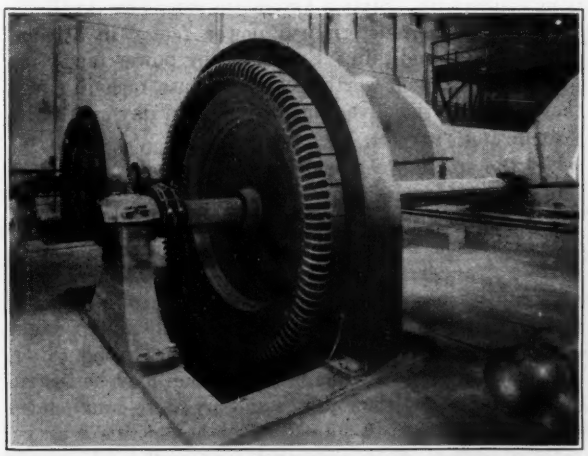


FIG. 1. 500-HP. SYNCHRONOUS MOTORS FOR PULVERIZING MILLS START ON FULL VOLTAGE

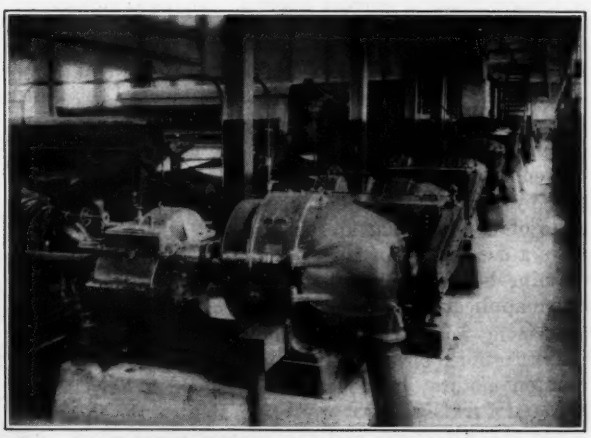


FIG. 2. PAPER MACHINE WITH 10 MOTOR-DRIVEN SECTIONS. COST PER TON FOR OIL AND MAINTENANCE 12 CENTS AS AGAINST 65 CENTS FOR MECHANICAL DRIVE

chronous for induction motors at certain key points in plants has materially helped the normal operation of all the other electric apparatus and has made it possible to add much needed motor loads within the heating capacity of existing transformers and feeders.

Time-delay undervoltage relays on all large motors are helping to maintain continuity of service. They allow motors to coast through voltage dips of short duration and save the wear and tear on the whole system which results from wholesale restarts after a momentary outage.

Wide and growing use of generator-voltage (Ward Leonard) control for d.c. motors in the presence of a.c. supply has done much to reduce maintenance and increase production. It is agreed that a d.c. machine may have a higher maintenance cost than a squirrel cage induction motor but considering control, motor and

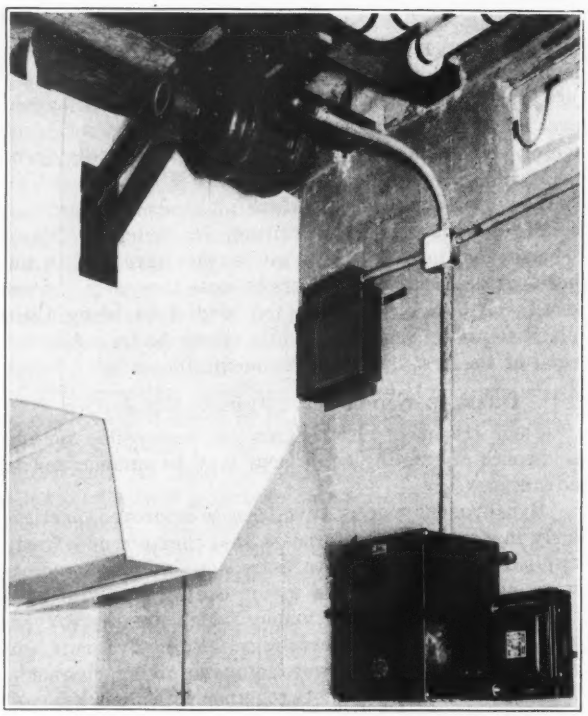


FIG. 3. VENTILATING FAN DRIVE BY SINGLE-PHASE SQUIRREL-CAGE MOTOR WITH ADJUSTABLE-SPEED CAPACITOR

driven machine, lower over-all maintenance cost often determines in favor of the d.c. generator-voltage control system. An example is the power shovel, which can be driven by a single or by several a.c. motors. It can be driven faster with less lost time and less maintenance cost by d.c. motors under generator-voltage control in spite of the fact that an a.c. motor is still required besides a d.c. generator for each motor. The same is true of mine hoists, steel mill main-roll drives and some 20 other applications common to industrial operations.

Among minor items are the more general use of an indestructible, one-piece winding for squirrel cage induction motors; improved bearings which have longer life and furnish better protection against the escape of oil to the windings; and the general practice of extra bracing of coils to withstand the stresses of full-voltage starting.

Full-voltage starting of motors has been extended to large sizes, 3000 hp. in one case and commonly to 500 hp. This permits simpler starting devices, consequently less maintenance, provided that the driven machine does not suffer from the mechanical shock that the quick start may inflict upon it.

Standard listed motors today are better protected from water, humidity, acid and alkali fumes and abrasive dusts than were the special motors of a few years ago. Research in these matters has resulted in the production of age-resisting insulations and better manufacturing procedure, thus producing better all-around units for all classes of electrical service.

Lightning protection has been the subject of much study and progress has been made in keeping with the efforts expended. Today, for instance, the transformer is practically lightning proof and outages from lightning surges are becoming increasingly rare.

Improvements in the design and construction of electrical units have carried with them corresponding improvements in spare parts, especially in the case of insulated parts which can now be kept in stock for long periods without deterioration.

Brakes and braking systems have changed for the better. Brakes require much maintenance and are often the unsuspected cause of maintenance expense in motors and driven machines. Alternating-current solenoids are now seldom used; electric-hydraulic brake releasers are taking their place. Motor generators are furnishing direct current to brake solenoids where, in many cases, a.c. solenoids were formerly used. Dynamic braking and regenerative braking are stopping thousands of shafts where formerly brake bands and wheels were being worn out.

Power factor improvement presents one of the most fertile fields for inside investigation. Additions, transfers and substitution of units can be plotted graphically to determine the effective means for power factor improvement with little expense. By such procedure one may find ways to better electrical conditions within the plant and often advantage can be taken of the power factor clause in the power contract. Means for improving power factor are found in the use of high-speed, fully-loaded induction motors, synchronous motors of unity or leading power factor, capacitors, or synchronous condensers. Simple automatic means are available for holding a predetermined power factor in a plant through thick-and-thin. Economies by power factor improvement are well worth seeking because, once in effect, they accrue to the advantage of the plant day and night, year-in and year-out.

If the spirit of critical scrutiny, which makes each unit prove its merit, can be popularized, something worth while will have been accomplished. Therefore, approach each unit in the plant as though it were a perfect stranger. Imagine meeting it for the first time. Look up its past records. Trade units around so that there will be fewer square pegs in round holes. Make everyone miserable up the line until the wrong things are made right. Thus maintenance men may be instrumental in keeping their plants at least up to equal status with competitors. In industrial plants in this country, only strenuous effort, long sustained, will hold a plant in a commanding position.

New Buffalo Terminal Plant

THREE 623-HP. BOILERS FIRED BY UNDERFEED STOKERS SUPPLY STEAM AND COMPRESSED AIR TO THE NEW RAILWAY TERMINAL ON LINDBERGH DRIVE, BUFFALO, N. Y.

IN THE FALL of 1929, the new railway terminal of the New York Central Railroad was completed at Buffalo, N. Y. This terminal, about three miles from the old depot, consists of the station proper, Post Office Bldg., American Express Bldg. and Pullman Car Shops. This group of buildings, and in addition coach yard with a capacity of some 500 coaches, is heated and supplied with compressed air by a new power plant consisting principally of three Erie City Iron Wks. 623-hp. longitudinal drum boilers fired by 6 retort Westinghouse Elec. & Mfg. Co. stokers and two 2500-c.f.m., 125-lb., Chicago Pneumatic air compressors, one steam and one synchronous motor driven.

Arrangement of equipment is well shown by the plan and cross section in Fig. 1, and photograph of the boiler aisle, Fig. 2B. Three boilers are installed at present, but the building is designed for a fourth unit and the boiler room is so laid out that a duplicate battery of four units can be added on the opposite side of the track from the present unit. Perhaps the most interesting feature of the station is the Link-Belt coal and ash handling arrangement. The railroad track extends through the boiler room and the coal cars are brought in and dumped in a track hopper indicated in the drawing. From the track hopper, coal is fed by an apron feeder through a double row crusher to a Peck carrier which elevates it to the individual boiler hopper. Each of these coal hoppers has a capacity of 45 t. Ash is raked from the ash hopper direct to the Peck carrier and dumped on a short feeder which discharges it to an ash hopper under the track.

Forced draft fans are located in the basement adjacent to the unit which they serve, while the boiler feed

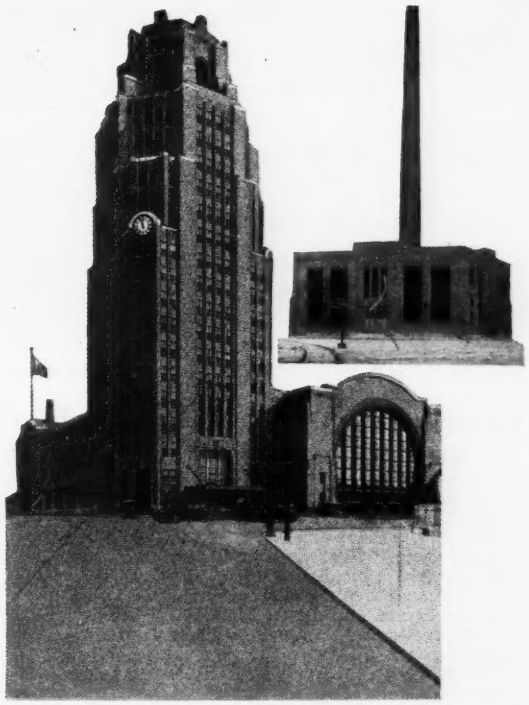


FIG. 2. EXTERIORS OF THE NEW TERMINAL AND POWER PLANT

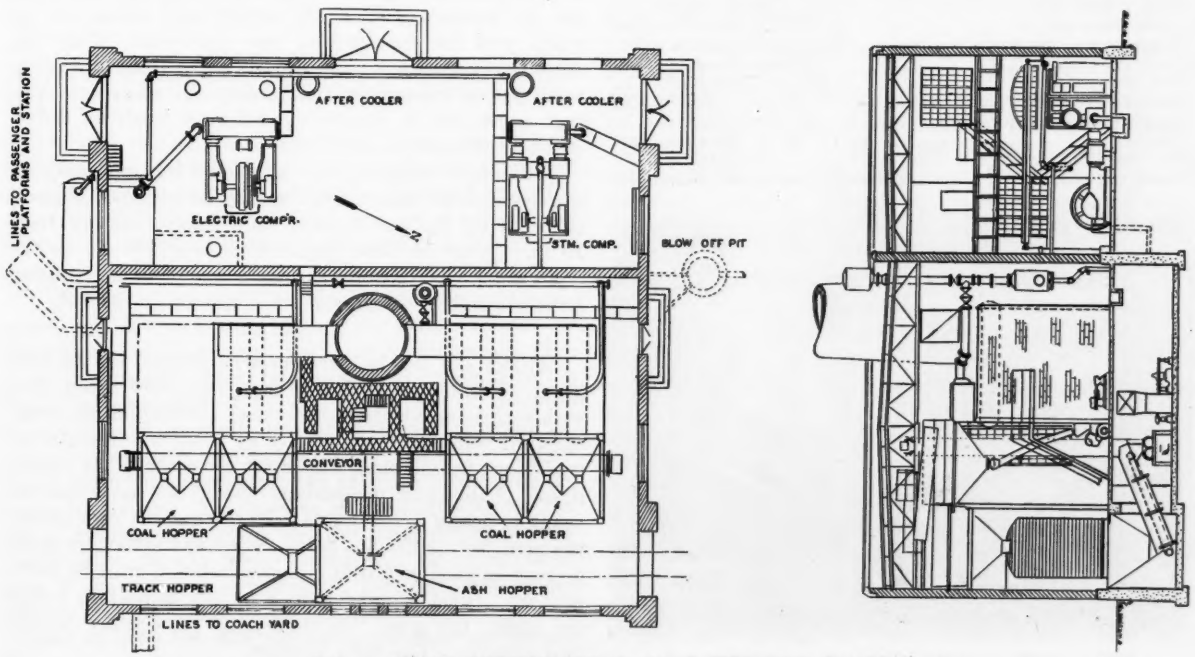


FIG. 1. CROSS SECTION AND PLAN OF THE NEW PLANT

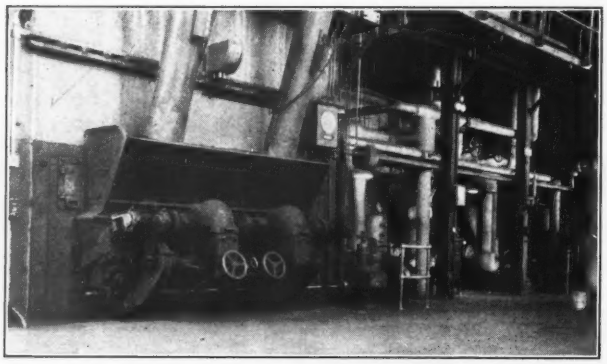


FIG. 3. THREE STOKER FIRED BOILERS ARE INSTALLED

Principal Equipment in the Buffalo Terminal Power Plant of the New York Central Railroad

3 Erie City Iron Wks. 623-hp. longitudinal drum boilers designed for 175-lb. pressure.
3 Westinghouse Elec. & Mfg. Co. 6 retort underfeed stokers driven by Westinghouse 4½ x 4-in., 2 single cylinder steam engines with a Walters governor.
2 Moore Steam Turbine Co., 300-g.p.m., 200-lb. head, 2 stage, centrifugal boiler feed pumps driven at 2790-r.p.m. by steam turbines.
2 Buffalo Forge Co. No. 5½ forced draft fans driven by Westinghouse 56-hp. steam turbine.
1 Moore Steam Turbine Co. 100-g.p.m., 200-lb. head service boiler and standby boiler feed pump driven at 3400-r.p.m. by a 23-hp. steam turbine.
2 Chicago Pneumatic 30/18 x 21-in. 125-lb. ga., 2-stage air compressor rated at 2500-c.f.m., one machine steam driven, the other driven by 2200-v., 580-hp. unity power factor 187½-r.p.m., 25-cycle General Electric Co. synchronous motor.
1 Cochrane Corp. V-Notch meter and heater with a capacity of 1000-lb. per hour.

Feedwater regulators ..... Swartwout Co.
Gage columns ..... Reliance Safety Water Column Co.
Gage cocks ..... Paul B. Huyette Co.
Safety valves ..... Consolidated Ashcroft Hancock Co.
Valves ..... Powell, Jenkins & Crane
Soot Blowers ..... Bayer Co.
Steam flow, air flow meters ..... Bailey Meter Co.
Draft gages ..... Bailey Meter Co.
Combustion control ..... Carrick Engineering Co.
Temperature regulators ..... Ruggles-Klingemann Co.
Pump governors ..... Fisher Governor Co.
Flow meters ..... Brown Instrument Co.
Pressure recorders ..... Bristol Co.
Compressor governor ..... Garrick Co.
Chimney ..... H. R. Heinicke, Inc.
Coal handling equipment ..... Link-Belt Co.
Steam traps ..... Strong, Carlysle & Hammond

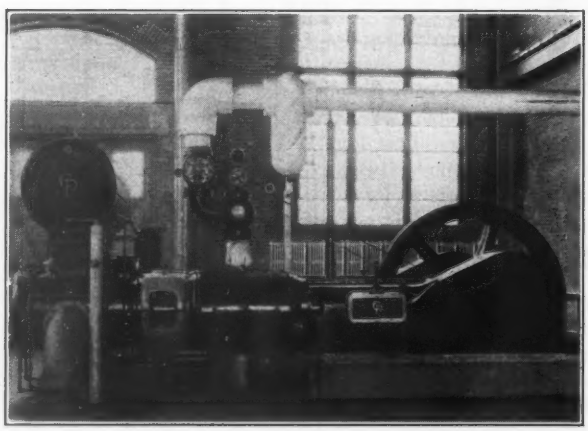


FIG. 4. ONE OF THE TWO AIR COMPRESSORS

pumps are located on the main floor immediately in front of the stack between the two boiler baffles. The feed water heater is located on a grating immediately above.

The plant was designed by the engineering department of the New York Central Railroad.

Importance of Rainfall Records

RAINFALL RECORDS, particularly the maximum flood volumes of streams are of great importance to the hydraulic engineer in the design of dams, reservoirs and embankments. Records are available for most districts in the United States. Excessive rainfalls are considered as those exceeding 5 in. in 24 hr. A storm in which all the rain falls in a meteorological day, i.e., from 8:00 p. m. to 8:00 p. m., is a one-day storm, likewise a two-day storm is one in which the rain falls in two such days.

Records show that the South Atlantic and Gulf states have the heaviest probable maximum. A curve plotted would run about 8 in. in 14 hr., 10 in. in 24 hr. and 13 in. in 48 hr. Northern and Central states show somewhat lower probable maximums ranging through about 7 in. in 16 hr., 8 in. in 24 hr. and 10 in. in 48 hr., winter maximum being lower in both cases through about 5 in. in 16 hr., 6 in. in 24 hr. and 8 in. in 48 hr.

Rainfall when the ground is frozen or covered with snow is particularly dangerous, because of the excessive runoff and the fact that the melting snow may increase the total equivalent by as much as 2 in. In New England, storms have been recorded with rainfalls of 4 in. in 2 hr. and almost 12.5 in. in 48 hr. Sometimes such high rates are local, sometimes widespread. One storm is recorded where 6 in. or more of rain fell over an area of 24,431 mi. In a small area of 179 sq. mi., rainfall in the same storm was over 11 in. So-called cloud bursts of the western states are much heavier but are usually local in extent.

Evaporation from water surfaces depends upon the temperature of the surface water and the humidity of the air immediately above it. The first depends upon the air temperature, depth, nature and extent of the water and its exposure to sun and wind, while the second depends upon the humidity and wind. In a given locality, the evaporation will follow the mean temperature curve but in comparing different localities differences in humidity must be considered.

Offhand it would appear negligible but especially on shallow storage basins this loss may be serious. Figures collected by the government show losses ranging from 20 in. a year in New England to over 100 in. in the Southwest. At Boston the loss is about 40 in. ranging from about 1 in. in January to almost 6 in. in July.

THERE ARE lots of yard hazards around the modern plant. Workers hurrying to and from work often meet with serious accidents in the yards. Switching demands constant watchfulness not only by those who handle the trains but by all those who must cross the plant switch lines. Autos and pedestrians travel the same narrow roads in many plant yards. Here again is emphasized the need for continuous care. Steps and stairways must be kept in good condition. Loose material must be gathered up. Good housekeeping is mighty important inside the plant, but good "yard-keeping" is equally important outside.—The Safe Worker.

Adding High-Pressure Unit to Improve Industrial Plant

NEARLY EVERY manufacturing establishment arrives at a point where it has to enlarge its power plant. Quite a bit of discretion has to be used to discriminate between the many ways it can be accomplished. Usually the

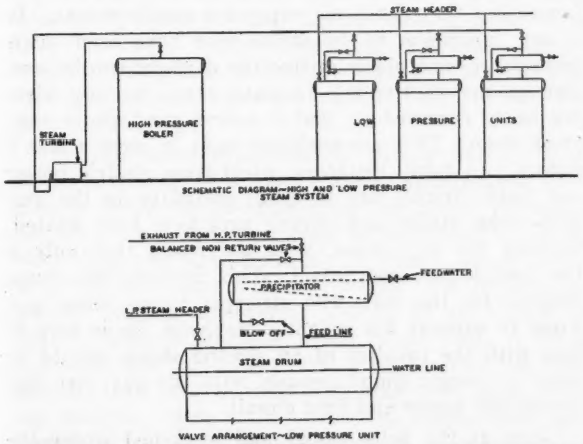


DIAGRAM OF HIGH AND LOW-PRESSURE STEAM SYSTEM AND VALVE ARRANGEMENT OF LOW-PRESSURE BOILERS

boilers and engines in the existing plant are in good condition and are able to serve for many more years, but other difficulties present themselves. In some cases, the space available is not sufficient for more boilers and engines or the plant doesn't measure up to the desired economy.

One way out of this dilemma is to use high-pressure steam, but few industrial plants can afford to do any experimenting or contend with the complication of a reheating system. Therefore, some sort of resaturation has to be accomplished, because to use 600 lb. pressure in a compound or multiple-expansion reciprocating engine, the cylinder condensation would offset any saving. If the steam is superheated, the cylinder lubrication becomes a problem. The turbine is more suitable for the use of superheated steam but the same difficulty with condensation in the lower stages will be encountered even if the steam is superheated, therefore, the writer believes a high-pressure unit should be used. Assume a plant of 2000 kw. and the owners wished to increase its capacity to 3000 kw. Then the addition should consist of high-pressure, steam-generating equipment having an evaporation capacity of 30,000 lb. of water per hour at about 600 lb. gage pressure; a 500-kw. turbo-generator taking steam at 600 lb. and exhausting at the pressure of the existing installation; and a 500-kw. turbo-generator taking steam at the pressure carried in the old boilers.

Now this article proposes a plan, unique in its installation, which will not require a reheating system but will give the same advantage in economy.

On top of the old boilers are to be placed precipitators. They are not new in principle, being used in some plants at the present time to heat the feedwater by means of live steam and precipitate scale forming impurities before the water goes to the boiler. The precipitator consists of a drum fitted with baffle plates so arranged as to cause a mixture of the steam from the boiler and the entering feedwater.

To use this equipment so that the exhaust steam from the high-pressure turbine can enter these drums, balanced nonreturn valves would be placed in the proper locations. Then either the exhaust of the high-pressure turbine or live steam from the old boilers could be mixed with the feedwater.

In laying out such a plant, the quantity of steam coming from the high-pressure side, should be about the same as can be generated in the low-pressure side, but on account of the higher water rate of the high-pressure unit only about one sixth of the power of the plant is generated with the high-pressure turbine when no process steam is needed. The saving, however, increases with the demand for process steam.

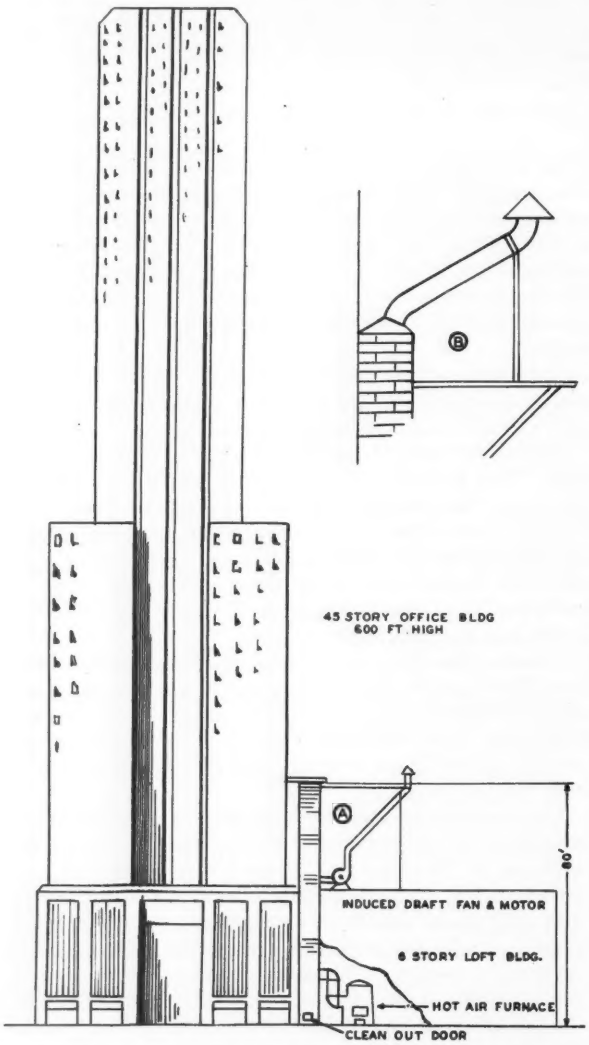
Inasmuch as the original plant remains as it was, the new plant would not decrease its reliability, in fact the high-pressure equipment could discharge directly into the low-pressure header without danger if the low-pressure units are supplied with steam separators of adequate capacity. Not much piping is needed and the balanced nonreturn valves will render this system automatic.

Chicago, Ill. OTTO QUENZEL.

Cooling Chimney Breaks Draft

ERECTION of a 45-story office building alongside of a six-story loft building, as shown in the sketch, caused trouble. When a fire was lighted in the hot air furnace in the loft building, the chimney would not draw and the loft building was filled with smoke.

Height of the skyscraper was blamed for the trouble so the owner gave orders to have the trouble corrected as shown at A in illustration. A piece of sheet iron was placed over the top of the chimney and a motor-driven, induced-draft fan installed on the roof of the loft building along side of the chimney, the discharge pipe extending away from the office building to carry the smoke away from the windows. Power for the fan was taken from the office building. After the installation, it ran



METHODS USED TO OVERCOME LOSS OF DRAFT IN CHIMNEY

continuously without requiring attention for 2 yr. but suddenly stopped without apparent cause. Upon investigation, it was found that the fire in the small hot air furnace, which supplied heat during the day in very cold weather to a furniture store on the first floor, had gone out, causing the chimney to become cold and damp therefore refusing to draw. After instructing the janitor to light paper at the clean-out door to heat the chimney before starting the furnace, no more trouble with the draft was experienced. The pipe on the roof was then remodeled as shown at B, the fan and motor being removed.

New York City. THOMAS SHEEHAN.

Some Aspects of Stack Safety

SOME WEEKS ago in Washington, D. C., the bronze statue of General Nathaniel Greene, located in Stanton Park for over 50 yr., fell from its marble base, a distance of about 12 ft. Investigation showed that the general's horse had been anchored to the pedestal by four ½-in. bolts. Some of these bolts had rusted away due to the action of the elements during the 50 yr. the statue had been standing. The intensely hot weather in Washington during the summer caused an expansion of the bronze hoofs of the horse with the result that eventually the bolts were sheared and the equestrian figure toppled over and crashed to the ground. As the result of this incident, all statues in Washington have been inspected to determine their stability.

It would be a good thing if a similar investigation were undertaken in connection with smokestacks. This matter has been brought to mind by the above incident, together with the valuable article by C. G. Crowley appearing in the August 15 issue on the subject of "Now Is the Time to Repair Stacks." The painter who mounts a stack to paint it is undertaking a dangerous job. Painters have lost their lives because sheet-steel stacks have been so corroded by acids from the fuel gas fumes that they could not support a man's weight. It is not uncommon to see stacks that have been eaten through in some places so that the daylight can be seen through the sheet steel! In many cases, the guy wires are badly corroded so that a severe wind storm may break them. They are obviously unfit to carry a man's weight. In many instances, wires from electric power and light circuits are in close proximity to the guy wires from stacks and electric arcs have been started, burning the guy wires, with the result that only a few strands remained intact. This, in turn, introduces hazards for the man who attempts to use these guy wires to support his weight. Moreover, he is face to face with the problem of an electric shock, should he come in contact simultaneously with the guy wire and the electric power and light circuit.

Just as the bolts rusted and weakened under the combined influence of the weather in the case of General Nathaniel Greene's statue, so bolts and base plates of stacks become corroded under the chemical action of coal dust, flue gas fumes and the elements, together with possible electrolysis. A number of serious accidents attributed to these causes have occurred from time to time, causing extensive damage to property and in many cases taking toll of human life.

As brought out in Mr. Crowley's article, a stack not in use may corrode more rapidly than one kept in constant use. There may be no justification for painting a stack that has come into disuse, especially if it is never to be used again, but it constitutes a potential danger. How often are stacks inspected to make sure that they are safe so far as pedestrians are concerned?

How often are stacks inspected by those who own them? What tests are made to make sure that everything is as it should be? What information is available as to the conditions found? How are these remedied and what is the technique? The writer knows of a number of very narrow escapes. He knows of several instances where serious damage was done. Surely here is a subject that deserves more attention and where one

engineer's experience may serve a useful purpose to many other engineers. It may suffice to paint a stack every 2 yr. But how should the damage be repaired, when discovered? What steps are engineers taking to discover any possible gradual deterioration that may be going on? A painter's job is to paint, cleaning the surfaces preparatory to applying the paint. How often is the painter's judgment depended upon to bring to light the developing of defects? Is the painter's judgment depended upon entirely or do engineers take other steps to keep tab on the condition of their stacks? Where corrosion is developing, what steps are taken to impede its action?

These questions are not as simple, perhaps, as they may seem. If they succeed in starting a line of thought as the result of which engineers will inspect their stacks or make a note on their memo pad to inspect them, it has accomplished its objective. Due to the depression of the last year, many stacks have stood idle, with the result that deterioration has been more rapid than would be the case if they had been kept in service. Danger lurks around some of these stacks. Prevention is better than cure and it will cost less to tackle the trouble when it starts than to overcome it once it has made considerable headway. Are smokestacks given as much attention as they deserve? Are they not treated as something that "stays put" after once being installed? Or are they looked upon as part of the plant that may deteriorate rapidly and cause extensive damage to life and property?

Perhaps some organizations having one or more stacks have adopted a policy of stack maintenance. Engineers would like to know what that policy is. Other engineers have had experience in combating corrosion, electrolysis and other troubles. Engineers would like to know how they handle their problems. Others have had narrow escapes, discovering defects in the "nick of time." Such experiences would be of value to other engineers who have left "well enough alone" or have devoted their time to what they considered more pressing matters. Here is an interesting subject that concerns every engineer at some time or other and about which practically nothing appears to have been written in the trade papers. Let's have these experiences.

Chicago, Ill. K. RANKIN.

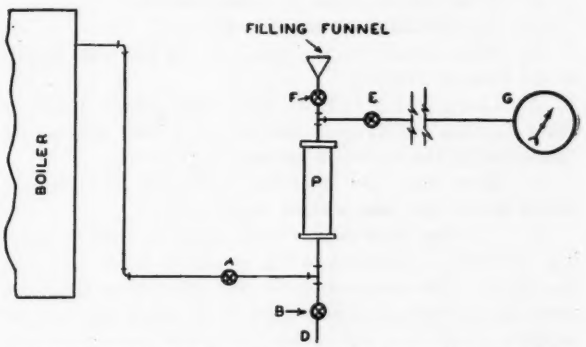
Oil as Pressure Medium Makes Distant Steam Gage Frost Proof

INSTALLATION of a pressure gage about 140 ft. from the boiler was made at a saw mill steam plant as illustrated to permit the log sawyer to know the steam pressure at his command at all times. When the gage and steam pipe froze solid during the first cold winter night after installation, it was necessary to install a new gage and new steam line.

Freezing of these parts on future cold nights was prevented in the following manner. After installing the new gage, G, and steam line as before, this line was cut and a piece of 6-in. pipe, P, about 12 in. long was placed on the line in a vertical position. The steam pipe from the boiler entered the large pipe at the bottom and a stop valve, A, was installed on the steam line close to the 6-in. pipe. The steam pipe entered the large pipe through the branch of a tee which was placed vertically and the lower end of the tee was closed by another stop valve, as shown, forming a drain, D, for the large pipe.

Screwed into the cap on the top end of the large pipe was a nipple which carried a vertically placed tee, from the branch of which the pipe leading to the distant gage ran almost out of doors. The steam pipe had a stop valve, E, close to the tee and another stop valve, F, was placed near the top end of the vertical tee. A funnel above this stop valve completed the installation.

Several gallons of an oil, which was of a nature that would not congeal at any winter temperature prevailing in the district, was poured into the large pipe through the funnel, the stop valves other than the one at the tee, being closed during the process. The stop valve, F, was then closed and stop valves A and E opened. Pressure was then turned into the oil-filled, 6 in. pipe and valve E opened to permit the pipe to be filled with oil when the steam gage was disconnected for a moment to permit



CONNECTIONS WITH OIL RESERVOIR SERVED TO PREVENT FREEZING OF LONG STEAM GAGE LINE

the air to be driven out by the oil pressure. After removing the "goose-neck," the steam gage was reconnected and boiler pressure soon registered on the gage.

As soon as oil appeared at the steam gage, the valves A and E were closed, valves F and B opened and the water condensation allowed to run out of the oil reservoir, after which valve B was closed and the reservoir filled with oil. Valves A and E were then opened and the apparatus was ready for permanent use.

One precaution must be taken; just as steam from the boiler is turned into the oil reservoir, valve A should be opened slightly to permit the water condensation but no live steam to be admitted to the oil reservoir. Live steam at high temperature might decompose some of the non-freezing oil and cause trouble.

Indianapolis, Ind. JAMES F. HOBART.

Station A—San Francisco's New 1400-Lb. Steam Plant

EVAPORATORS for this station were supplied by the Foster Wheeler Corp., instead of by the Cochrane Corp. as reported in the list of equipment accompanying this article on page 664 of the June 15, 1930 issue.

BEFORE PACKING pumps, the packing should be soaked overnight.

Questions and Answers

Electric Welding Technique

FRANK P. MCKIBBEN of the General Electric Co. has prepared a list of questions and answers for a training course in electric welding from which the following have been selected:

1. What is electric arc welding.

A. Welding in which two pieces of steel are melted together by the electric arc.

2. What are the base or parent metals?

A. The materials to be welded.

3. What should be the condition of the base metals at the time of welding?

A. Clean and free from rust, dirt, grease, paint or other foreign substances, except for a thin coating of linseed oil if the engineer has specified its use.

4. How does the operator form the electric arc which melts the base metals together?

A. (a) One wire cable (lead) from the electric welding machine is fastened to the electrode holder held in the hand of the operator, while the other wire from the machine is attached to any part of the steel pieces to be welded;

(b) The end of the welding wire is touched to the steel parts, where the weld is to be made, and current flows;

(c) The wire is then withdrawn about ⅛ or ¼ in. away and the electric arc is formed.

5. Which welding lead, positive or negative, is ordinarily connected to the electrode holder when welding structural steel?

A. The negative.

6. What type of welding current, alternating or direct, is ordinarily supplied to the welding operator for use in structural steel welding?

A. Direct current is almost exclusively used for arc welding structural steel.

7. What precautions must be taken by the operator, while welding, or the inspector of welding while watching the welding process?

A. The arc should not be looked at without covering the face and neck with a helmet; in which is a darkened glass for protecting the eyes against the arc. The welder should also wear gloves to protect his hands.

8. Which is preferable—a short arc or a long arc?

A. A short arc because it makes a purer weld, gives better fusion and penetration, and causes less spattering of the molten metal.

9. What does the voltmeter on the electric welding machine indicate?

A. The voltmeter indicates the voltage or electrical pressure; somewhat as a water pressure gage shows the water pressure in a pipe line.

10. What does the ammeter on the electric welding machine indicate?

A. The ammeter indicates the amperage, that is, shows the number of amperes, or quantity of electric current flowing; somewhat as a water meter records the quantity or amount of water flowing through a pipe.

11. Does the needle on the voltmeter record the same amount all the time?

A. No. When the welding operator is welding, the needle on the voltmeter records a small number of volts. When he is not welding and the machine is running idle the needle records a larger number of volts.

12. Does the needle on the ammeter record the same amount all the time?

A. No. When the welding operator is welding, the needle on the ammeter records a large number of amperes. When he is not welding and the machine is running idle, the needle stands at zero.

13. Is there any way by which the welding operator can regulate the amount of current, that is, change the amperage, in order to get more or less current as required for welds of varying sizes?

A. Yes. On each machine is a small crank or similar device, which can be turned in such a way as to furnish more or less current and therefore more or less heat, to the welder.

14. Does a welding operator in welding thick steel require more current, that is, more heat, than when he is welding thin steel?

A. Yes. The thicker the steel parts to be welded, the greater is the amount of heat required, and the current must be greater than when welding thin steels. The thicker the steel, the greater should be the amperage.

15. How is a butt welded joint made?

A. For thin plates, say ¼ in. thick or less, by placing the edges of the plates almost but not quite together and melting them together by the arc. For thicker plates, before applying the arc, the edges to be welded should be beveled.

16. How is a fillet weld made?

A. Fillet welds are used where one plate to be welded is lapped over the other, and the two joined together by depositing with the arc a mass of metal against the edge of one plate and against the side of the other, forming a fillet.

17. Is a fillet of good smooth appearance free from small gas holes, better than one with a very rough surface and badly pitted with gas holes?

A. Yes, smoothness of surface and freedom from gas holes indicate better workmanship and stronger welds.

18. What precautions should be taken to insure good welds?

(a) Employ only welders who have satisfactorily passed qualification tests to show their skill in welding.

(b) From time to time during progress of the work,

in order to maintain a high standard, require each welder to make additional tests.

(c) See that the welding wire conforms to the requirements of the specifications and shows good welding qualities.

(d) Inspect the welds while being made to see that the operator is holding a short, steady arc and using the proper amount of current.

(e) Examine the finished welds and accept only those having a smooth appearance free from gas holes or porous places; see that the crater shows that the weld has properly penetrated the base metals; see that the edges of the deposited metal are sharp and indicate good penetration into the base metals.

19. About what current should be recorded on an ammeter of a welding machine when the welding operator is depositing a ⅜-in. fillet? For depositing a ¼-in. fillet?

A. For depositing a ⅜-in. triangular fillet, a current of from 175 to 200 amp. should be indicated on the ammeter. For ¼-in. fillet, a current of from 150 to 160 amp. should be indicated.

20. Approximately what amount of current should be used with $\frac{5}{32}$-in. diameter electrodes? With $\frac{3}{16}$-in. diameter electrodes?

A. This depends somewhat on the thickness of steel to be welded but generally 150-200 amp. for $\frac{5}{32}$-in. diameter electrodes and 175-225 amp. for $\frac{3}{16}$-in. diameter.

21. How should a condemned weld be removed in order to permit the joint to be rewelded?

A. The weld metal should be cut out either with a compressed air tool or by hand.

Rated Boiler Horsepower Calculation

PLEASE LET ME know the process, step by step, required to find the rated horsepower of a horizontal return tubular boiler whose diameter is 70 in., length 16 ft., which has sixty 4-in. flues. R. T.

A. To compute the heating surface of a return tubular boiler, we figure the surface which has water on one side and hot gases on the other. For this we assume ⅔ of the inner surface of the shell plus ⅔ of the projected areas of the two heads minus the areas occupied by the tubes plus the combined areas of the outside surfaces of all of the tubes.

This is given by the formula

$$HS = [\tfrac{2}{3} \times 3.1416\ DL + (2 \times \tfrac{2}{3} \times \tfrac{1}{4} \times 3.1416\ D^2 - 2N \times \tfrac{1}{4} \times 3.1416\ d^2) + 3.1416\ d\ l\ N] \div 144$$

$$= (2.0944\ DL + 1.0472\ D^2 - 1.5708\ d^2N + 3.1416\ d\ l\ N) \div 144$$

where D = diameter of boiler shell, in. = 70

L = length of boiler shell, in. = 16 × 12 = 192

d = diameter of tubes, in. = 4

l = length of tubes, in. = 192

N = number of tubes = 60

$$HS = [(2.0944 \times 70 \times 192) + (1.0472 \times 70^2) - (1.5708 \times 4^2 \times 60) + (3.1416 \times 4 \times 192 \times 60)] \div 144$$

$$= (28{,}250 + 5130 - 1507 + 144{,}765) \div 144$$

$$= 1237 \text{ sq. ft.}$$

The rated horsepower based upon the heating surface is found by dividing the total heating surface by 10. It is assumed by this that a boiler operating under normal conditions will evaporate 34.5 lb. water per hour from and at 212 deg. F. for every 10 sq. ft. of heating surface.

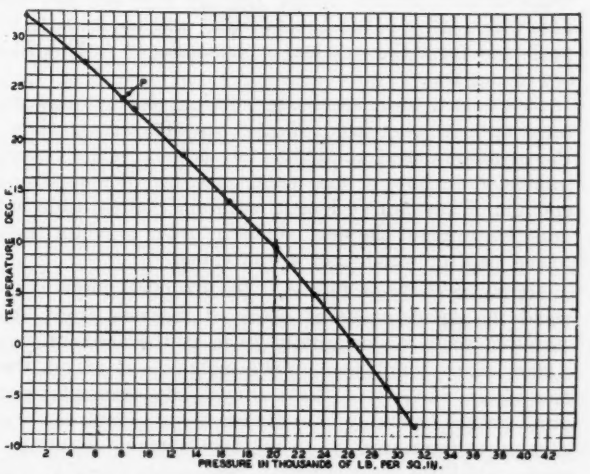
Therefore 1237 ÷ 10 = 123.7 or say 124 b.hp. (rated).

In the foregoing calculation, all dimensions were assumed to have been taken inside of the setting, which follows the definition of heating surface and the length of the tubes was taken as the length of the shell, which is usually the practice in horizontal return tubular boilers.

Effect of Pressure on Freezing Point of Water

CAN YOU TELL me the amount of air pressure necessary to reduce the freezing point of water to 24 deg. F.? C. A. Y.

A. From the curve illustrated, which was plotted



CURVE SHOWING RELATION OF PRESSURE AND FREEZING POINT OF WATER, PLOTTED FROM TAMANN'S, 1900, VALUES

from Tamann's, 1900, values as published in Handbook of Chemistry and Physics, 13th edition, by Hodgman and Lange, we find the pressure corresponding to 24 deg. F., as shown at point, P, to be 7800 lb. per sq. in.

O. G. Rings on Manning Boilers

WHY ARE O. G. rings used on Manning boilers? M. S.

A. Manning boilers, being of the vertical type, are restricted in grate area. The O. G. ring makes possible a larger grate area than would be possible if the sides of the boiler were straight throughout its entire height.

Expansion and contraction between the furnace and shell due to heat changes, also, are more easily taken care of by the O. G. construction than would be the case otherwise; thus strains on joints are reduced.

STAINLESS IRON has a carbon content of less than 0.12 per cent and contains less than 16 per cent chromium. It has a high tensile strength, can be easily forged, machines readily when annealed, is corrosive resistant without heat treatment, can be hardened and tempered, but it is difficult to weld and riveted construction is to be preferred.

Editorial Comment

The Age of Alloys

Not content with leading us into an Age of Steel and an Age of Power—both dependent on each other—science is now taking us into what will probably be called the Age of Alloys. In that forthcoming Age, new types of metals and new uses that will be found for them promise reduction of the tremendous losses caused by rust and corrosion, possibility of attempting types of engineering structures not feasible with the metals we have now, conduct of industrial processes in new ways and at lower costs and, not least in importance, new types of architectural design, interior trim and exterior decoration using natural metals that will not have to be protected from the weather or camouflaged to look like something else.

Steel used to be steel and nothing else but now we must specify what kind of steel we are talking about. Power plant engineers used to tell us they weren't much interested in how it was made, provided it was strong enough. They can no longer maintain that attitude but must learn about the new metals in order to adapt them to the uses for which they are intended.

It is the irony of fate that the strongest impetus toward the development of many of the new irons and stainless steels was originally given by the needs of war. Armor plate, toughened by the inclusion of nickel, was one of the earliest of these alloys. Experiments with gun linings, notably by Brearley in England and Strauss in Germany, led to the development of stainless steels that have great strength, reasonable ductility and resistance to corrosion.

Already many of these alloys have been applied to the uses of industry. They have proved invaluable in the food and dairy industries, in hotels and restaurants, for automobile trimmings and parts, in the oil refining and chemical industries and most spectacularly in some of our newest large buildings. There is hardly a branch of industry known in this country that has not already used in some way the various new types of iron and steel.

Besides these, there will doubtless be developed an infinite variety of alloys of other metals that will greatly extend our ability to solve future engineering problems. For example, announcement was made some time ago of a new alloy of cobalt, nickel and ferrotitanium that is stated to increase in strength as its temperature increases, attaining a tensile strength of 60,000 lb. per sq. in. at a temperature of 1112 deg. F. If this metal is all that is claimed for it, its possibilities in the development of power plant equipment operating at high temperatures are obvious.

Thus the discovery of all these new metals promises a new era. In industry, permanence, rather than constant replacement, may come to be the rule. In building work, new styles using these metals in natural form will break down much inherited tradition. What the effects of these things will be no man can predict. The factor of obsolescence has had a most important effect on the present pace of industry. What if the new Age of Alloys proves to be characterized by equipment of all kinds that will last a long time and give efficient service throughout that long life?

The present tremendous expansion of industry has given rise to a philosophy of making many products to give good service over a comparatively short life, as opposed to the philosophy of our grandfathers who made a few things to last as long as possible. Modern industry has, of course, created products and habits of life undreamed of before. What if the new Age of Alloys brings about a combination of these two philosophies? Whatever it produces, the New Age of Alloys will be a fascinating one.

Process Heat Supply and Power Production

In the average small steam plant having a considerable demand for process steam, the value of power analysis, hence that of keeping accurate power records, is proportionately great; yet rarely are adequate power records found in such plants or opportunity for the necessary analysis provided.

In a recent investigation of New England manufacturing plants, undertaken by coöperation of the Massachusetts Institute of Technology and the Industrial Committee of the New England Council, it was found that a majority of the plants using process steam were not generating their own power. Most of these plants, it was found, could produce their power economically, if they were able to finance the necessary equipment. In some cases, an annual saving of approximately 33 per cent on the investment could be realized.

In all the plants investigated, there was a dearth of recording instruments and, where instruments were used, there was almost a total lack of compilation in useful form of recorded information.

That many small plants generating their own power, especially those requiring process steam, can effect considerable savings by bleeding steam turbines for this service is now generally known to those who have investigated the subject. By this method, it has been pointed out, a kilowatt-hour can be generated in a properly equipped and managed power plant with 0.4 lb. of coal at a cost of four mils and savings up to 60 per cent of the fuel cost of power made by exhausting turbines to processes requiring steam, thus using the turbines as reducing valves.

Usually, however, the small plant suffers not only from inadequate financing, which fails to provide a source to be drawn on for necessary refinements and improvements or for professional investigation by competent engineers, but also from lack of foresight by the manager which prevents, in most cases, any investigation by its own chief operating engineer, through inade-

quate provision of time to study possibilities and keep up to date on methods which are used in other plants.

Managers of manufacturing plants are so engrossed in reducing manufacturing costs that they do not comprehend the savings that may be realized by a properly designed and operated power plant for their particular needs. Installation of adequate power records is one of the first prerequisites to betterment but application of improved methods cannot be made intelligently without careful analysis of those records in the light of thorough knowledge of what is being accomplished in other plants.

Has Safety Reached Its Limit?

During the year 1929, more than 400 employes of electric light and power companies were killed while in the service of their employers. This rather startling figure represents a fatality rate of 1.4 per thousand employes, a reduction from 1.7 per thousand seven years ago but for two years no reduction has been accomplished. Has the industry reached the point where the efficiency of safe practices and safety devices is nullified by the carelessness of employes? Do employes place undue confidence in safety provisions or do they take unwarranted risks in the efforts to serve their employers? Whatever the cause, the victim pays the penalty.

Few workmen will knowingly expose themselves to risks without what they consider good reasons for doing so but, in every organization every workman cannot personally investigate every avenue of danger surrounding the task at hand, he must depend to some extent upon the knowledge and integrity of those with whom he is associated. One untrustworthy man in the crew makes danger imminent. This also applies to the novice, the joker, the kidder, the fun maker or anybody who needlessly attracts his associates' minds from their task; for it is in such unguarded moments that accidents happen or that the stage is set for one.

No matter how trivial a safety rule may seem, it should be implicitly obeyed for somebody else may be depending upon the carrying out of that rule for his safety. Foremen and superintendents in charge of workmen are essentially the enforcers of safety rules and as such they must instruct, train and discipline their men in the safety rules laid down by the executives of the company which in the end must assume moral and financial responsibility for its employes while carrying out the task set for them.

Safety is largely a matter of education and discipline, surely fatalities in the electric light and power industry can be reduced below 1.4 per thousand employes.

Off Duty

Way up in the northern wide open spaces, where rivers have swift water in them, and dams are often vocifierous and spelled the other way, they wanted one of the hydraulic kind. But they had a wild baby, the Saguenay River, on their hands. It was cradled in a rocky gorge which made it wild, free and fast. So putting it in a crib, even of heavy timbers weighted with stones to keep the strenuous child from shaking them loose didn't seem feasible. Yet they had to divert this restless youngster some way from his original bed and coax him into a byway while fixing foundations and spillways and what not to control his riotous ways so that he might become a useful member of society. It was all comparatively easy going to make the byway for this roisterer to travel but how was he to be induced to go travel there, being as how he was of the wilds and liked his own wild way?

Came James W. Rickey and says he, "We'll just distract his attention and jump his claim when he's not expecting it."

So they built an obelisk, not like the ones of Cleopatra's time but an ungainly looking affair. It was on the river bank, stood on a concrete pier and had the side away from the river a nice straight vertical line while the side which the river baby saw was queer, with small foot, a most aggravated waist line and a dumpy shoulder. No wonder the river, jeering at the workers as it shimmied in its cradle, had no notion that this queer outline was shaped to fit the bottom of the gorge and end his wild hilarity.

How would you like to bet a lot of dollars that you could build a monument 92 ft. high, 45 ft. wide and some 45 ft. thick, then flop it over into a river and that it would land right and fit and stay put?

Probably Mr. Rickey felt the same about it. Anyway he figured, his staff figured, then they all checked each other's figures. The idea was to blow away one corner of the supporting pier so the dam on end would fall down and go boom. It sounded feasible but would it land where it ought? Better try it. So a model was built and the pier blown out and movies taken of the performance. Then slow motion was used to study just what happened and where the dam brought up finally.

Meantime the diversion channel was built, a sort of primrose path for the roistering river also a permanent dam in the channel with gates to carry the river into its new domicile, 50,000 cu. ft. a second is some gulp, even for an open outlet channel. Also, some water was to be left flowing down the old channel as a cushion to break the fall of the dam when it dived.

Well, everything was ready. The figures were checked,—O.K. The model had landed,—O.K. The pier had been separated in two parts and the part to be blown out was loaded with dynamite. Where would that dam be *after* the dynamite blew up? Probably Mr. Rickey took a deep breath and held it when the charge was set off.

There she goes! Maybe you've seen a big tree felled and thrilled at its majestic swoop. Picture a concrete tower, 95 ft. up, 45 ft. wide and thick doing the same thing, into a fast flowing river. Some splash. But it landed, practically as intended and the turbulent wild baby was tamed.

Then Mr. Rickey likely took another deep breath and said, "Thank goodness, that's that." Or did he?

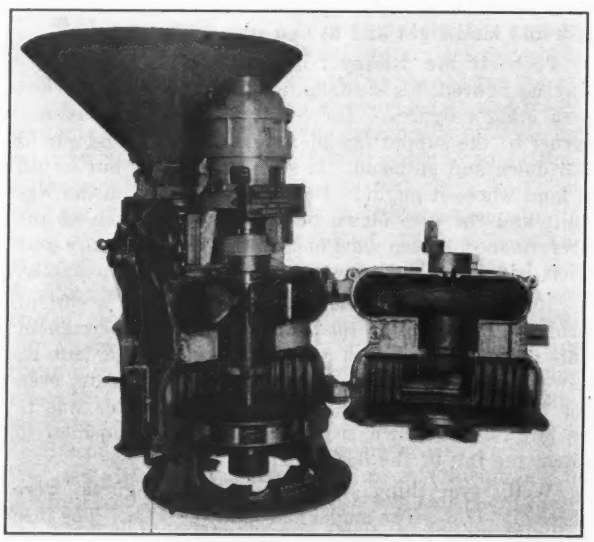
Ingenuity, careful planning, precaution but the daring to use new methods to meet new problems. By such does successful engineering achieve its ends and make progress.

Dr. James Aston, director of mining and metallurgy at Carnegie Institute of Techology, is the inventor of the new process for mass production of pure wrought iron, oldest metal known.

Power Plant Engineering Developments and News

No. 3 Unit Pulverizer and High-Low Velocity Burner

FOR GENERAL industrial use with boilers and industrial furnaces, the No. 3 Whiting unit pulverizer has recently been placed on the market. It is designed with the following characteristics: Capacity, 30 to 800 lb. an hour; power, 7½ or 10-hp., 1800-r.p.m. motor;



NO. 3 UNIT PULVERIZER WITH CASING OPEN TO SHOW HAMMERS AND EXHAUSTER

average fineness, 95 per cent through 100 mesh screen. It consists of a raw coal feeder, a magnetic separator to eliminate tramp iron; a high-speed one-stage hammer pulverizer; a separator to allow only finely pulverized coal to be blown to the burner; an exhauster that also supplies combustion air.

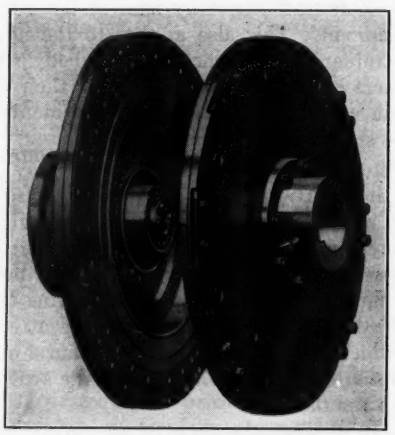
The unit is designed to operate on the air separation principle. Adjustable manganese steel liners and hammers are fitted, designed to give maximum length of service and a convenient control of raw coal is provided. The new unit, as shown, is a product of Whiting Corp., Harvey, Ill.

This company has also developed a new high-low velocity pulverized coal burner, designed originally for annealing ovens in which the fuel required for holding an even temperature is only about 12 per cent of that needed for heating it up to that point. To obviate the need for two burners, this unit was developed, consisting of two concentric parts provided with two adjustable dampers. These are made so that either the outside annular space, the inside tubular space, or the whole section can be used to control the flame by reducing or increasing the velocity of the coal and air mixture or to maintain the same flame length by reducing the section when less coal and air are used.

Magnetic Clutch

CONSISTENT operating characteristics, easy installation, safety and easy access to parts which may have to be renewed are claimed for a new line of magnetic clutches announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis. These new clutches are known as the Type L, because of the shape of the armature, the cross-section of which is L shaped so that it fits around the magnet coil. This is intended to give steady magnetic pull throughout the life of the lining.

The magnet coil is wound on a sheet metal form and vacuum impregnated before it is inserted in the field



MAGNETIC CLUTCH SHOWING CENTERING BEARING

member. The coil is locked in place by four mounting studs which extend through the field casting. Loosening the four studs allows removal of the entire coil. All coil terminals are recessed below the surface of the field member to protect them against damage.

A centering bearing, which is a roller bearing mounted in the field member, protrudes so that it fits into a recess in the armature hub, to form a common support for both clutch members, yet to allow either member to revolve independently of the other when disengaged. This is to assure perfect alinement and concentric engagement of the members.

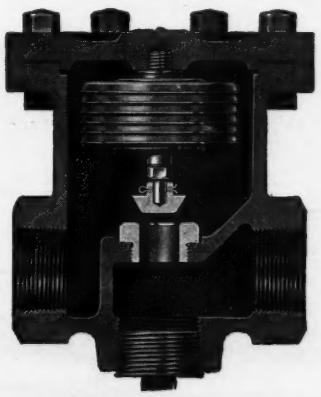
Improvement has been made in the design of the collector rings for these clutches. These are made of

brass to prevent corrosion and are mounted away from the hub, on four insulated studs, to prevent dust from collecting to cause creepage between the rings. Two carbon brushes are used on each collector ring so that one brush is always in position to give good contact without arcing. A lining wear indicator is provided to show the operator when the lining has worn to a point where it must be readjusted.

Industrial Steam Trap

DESIGNED for application to heating systems, laundry and cooking apparatus and process steam equipment, the Nicholson industrial steam trap shown here has recently been placed on the market. It is made for pressures from 0 to 100 lb. in sizes from ½ in. to 2 in. At 100 lb. pressure, capacities range from 7720 lb. per hr. to 70,500 lb. per hr.

The actuating element is a large diameter bellows, the valve being made to close by the resilience of the bellows when inside and outside pressures become balanced. This is intended to occur when steam is present



SECTION OF NICHOLSON INDUSTRIAL STEAM TRAP

in the trap. Water in the trap dissipates the internal pressure and the valve opens instantly, it is stated, because of the pressure difference thus established. The trap is designed to discharge automatically any air that accumulates in the body and is wide open when cold. It will lift the discharge water 2 ft. vertically, it is claimed, for every pound of pressure in the trap after the first 5 lb. By changing the pipe plug from bottom to side, the trap can be used either as an angle or straight through trap. It is built by W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

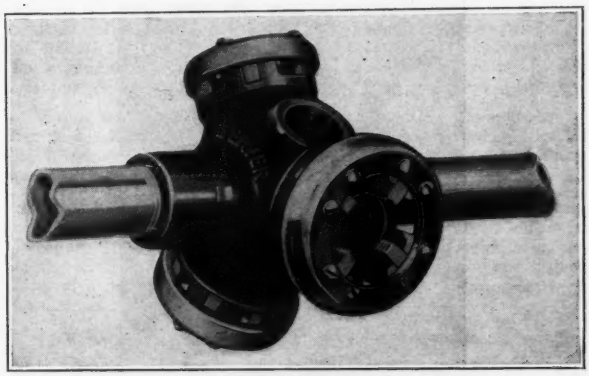
Pipe Tubing Bending Machines

TWO NEW TYPES of pipe bending machines, one for ¾-in. to 2-in. standard gage pipe, the other for tubing up to 1¼ in., as shown, have recently been placed on the market by American Pipe Bending Machine Co., Inc., 37-39 Pearl St., Boston, Mass. The type H-29 motor operated cold pipe bending machine, Fig. 1, is designed for bending steel, wrought iron, brass and copper pipe without crimping or splitting. Power is supplied by a 2-hp. G. E. motor; through gearing this power is applied to a cam shaft and, in turn, by cams and toggles, to the pressure shoe. This mechanism is designed to apply great pressure evenly to the pipe and to permit making 45-90-180 bends, offsets, compounds and so on.

Hand power is used for the Type V thin gage tubing bender, Fig. 2, designed for bending steel, brass and copper tubing (annealed) to radii usually needed without heating or filling the tube. This work is done by a system of newly-designed mandrel guides in all O.D. sizes up to 1¼ in. Scale stop is provided for bending a number of pieces to the same curve. Each size of tubing to be bent requires four rolls, one bending disc, one mandrel, one mandrel rod and one follower.

3-Way Die Stocks

BEAVER 3-way die stocks as shown herewith have recently been developed by The Borden Co., Warren, Ohio. They are built in sizes No. 33 for ⅜, ½ and ¾-in. range and No. 34 for ½, ¾ and 1 in. Die



3-WAY DIE-STOCK

segments are electrically heat-treated, square without shoulder or offset. Dies are driven by the solid body of the tool. Large openings are provided to facilitate oiling and give chip clearance. Die retaining ring of pressed steel and heavy, long, handle bosses are used. Dies and die retaining rings are made to be interchangeable with the No. 3 Beaver.

Full width dies are intended to serve equally well for threading steel, wrought iron or brass pipe. For threading short nipples in emergencies, the design provides for inverting the dies.

Enclosed Fan-Cooled Induction Motors

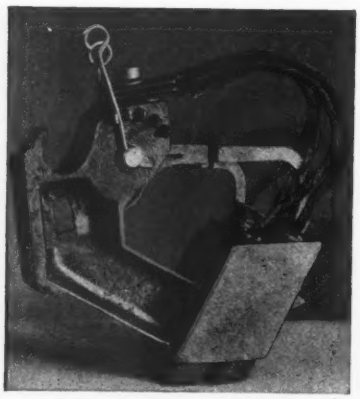
LINE OF fully-enclosed fan-cooled induction motors in sizes of 20 hp., 1200 r.p.m. and above for which the Mossay Principle of cooling is used, has been announced by the Reliance Electric & Engineering Co., Cleveland, Ohio. This method of cooling is employed for the larger sizes because the design of the smaller motors does not provide sufficient cooling area. The extra cooling area is obtained by use of tubes extending over the outside of the stator. A single internal fan on the rotor is provided to circulate the confined warm air through the tubes over which are blown blasts of cool outside air from one end of the motor to the other.

Use of this method of cooling for the large sizes, it is stated, makes it possible for the company to furnish fully-enclosed fan-cooled motors which are interchangeable in mounting dimensions with its standard open motors of the same horsepower and speed rating.

Stator windings and rotor are tightly enclosed; fits for all enclosing parts are machined surfaces; all seals are stationary.

New Brush Holder Which Prevents Sparking

TO AVOID THE possibility of sparking between the brushes and the commutator of heavy current electrical rotating machines, a new double brush holder of die cast construction has been developed by the Westinghouse Electric and Manufacturing Co. The two individual brushes in this double brush holder are never



bounced off the commutator at the same instant, and one or the other of them is always in contact with the commutator.

A difference in height between adjacent commutator bars of as little as one ten-thousandth of an inch is sufficient to cause a single-block carbon brush to bounce out contact with a high speed commutator an amount sufficient to develop a brush drop of about 20 v. between the brush and the commutator. This bouncing of a single brush on a rough commutator is equivalent to a partial opening of an electric circuit and the sparking that results is entirely independent of the design characteristics of the winding, being due solely to a mechanical cause; therefore, a brush holder which maintains constant contact between brush and commutator is an important factor in good commutation.

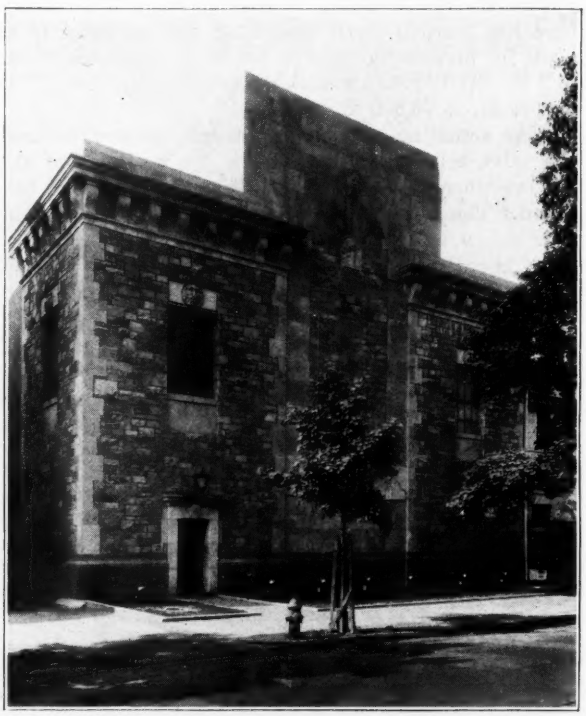
W. J. BERTKE, president of the Sioux City, Iowa, Gas and Electric Co., has announced acquisition of the Dakota County, Nebraska public utility properties, valued at $75,000 by the Central West Public Service Co., Omaha. The properties become part of the Nebraska Public Service Co., operating subsidiary of the Sioux City Gas and Electric. Reconditioning and extensions are contemplated, Mr. Bertke announced. Current will be supplied from the Big Sioux power plant.

PRODUCER GAS engines are generally guaranteed on a basis of coal used per horsepower-hour.

Attractively Designed Substation in Washington, D. C.

DUE TO THE GOVERNMENT requirements in the development of the new building project within the so-called "Triangle" in Washington, D. C., the Potomac Electric Power Co. has been compelled to vacate its offices and operating buildings on Fourteenth St. and, as a result, have constructed the new substation shown in the accompanying photograph.

While the exterior is severely plain, the interior contains a substation that embodies all the modern features



NEW SINCLAIR SUBSTATION OF THE POTOMAC ELECTRIC POWER CO.

known today for the operation of a direct current station. It consists of the basement, machine and mezzanine floors and roof with pent houses.

An outstanding feature of this station is the absence of noise. This is accomplished by keeping the machines and their foundation separate from the building structure. By providing large reënforced concrete pans between the building footings and lining these pans with isolation cork before pouring the concrete footing for the machine foundation, leaving a small slot between the machine floor and the individual machine decks at the machine floor level and inclosing the machine in a sheet steel housing, for forced ventilation, much of the noise ordinarily produced by equipment of this type is eliminated.

The air for these machines is drawn down from the pent house on the roof, and forced into a large air chamber in the basement directly under the machines by six centrifugal fans. The air is then drawn into the machines, and exhausted through a sheet metal duct into the central part of the pent house. Each fan has a capacity of 35,000 c.f.m.

News Notes

WARREN MAXWELL has been appointed superintendent of the Dodge Works of Link-Belt Co., succeeding F. J. Oakes, deceased. Mr. Maxwell, a graduate of the U. S. Naval Academy, has been with the company since 1922, at first in the sales department and later as assistant superintendent.

WITH PROFOUND SORROW L. J. Wing Mfg. Co., New York announces the death of its secretary and treasurer, Victor H. Carples, on Wednesday, September 3, 1930.

ANNOUNCEMENT is made of the removal of the executive offices of the Central Public Service Corp. to 224 South Michigan Ave., Chicago, Ill.

ANNOUNCEMENT has been made in the New York territory of new partnership known as Striegel & Jefferson, Inc. This new incorporation brings together the two following sales engineers: Ed. H. Striegel, formerly with Furnace Engineering Co., Inc., New York; Union Iron Works, Erie, Pa., and for the past two years New York representative of Drake Non-Clinkering Furnace Block Co., Inc., New York. E. R. Jefferson for the past 11 yr. with Bernitz Furnace Appliance Co., Boston, Mass., 8 yr. as its New York manager. Equipment represented by Striegel & Jefferson, Inc., includes the complete line of Drake Non-Clinkering Furnace Block Co., Inc., New York and King Refractories Co., Inc., Buffalo, N. Y.

This new office will be located at No. 5 Beekman St., New York City.

PHILADELPHIA sales office of Cutler-Hammer, Inc., is now located on the 10th floor of the new Terminal Commerce Building, 401 North Broad St., Philadelphia, Pa., according to a recent announcement. These new quarters also include warehouse facilities. F. J. Burd is manager of the Philadelphia district.

T. B. NUSSEY has recently joined the Stone & Webster Engineering Corp. at its Boston office as engineer in the Appraisal Division. Previous to this connection Mr. Nussey had been associated with Jackson and Moreland, Forestall-Robinson & Luqueer, and the Long Construction Co.

FULLER LEHIGH CO., Fullerton, Pa., announces the removal of its Cincinnati office on October 1, from the Traction Building to Carew Tower, Cincinnati, Ohio. H. E. Martin will continue in charge as manager.

FRED G. SCHNEEBERG, JR., has succeeded E. R. Jefferson as district sales manager of the New York office of the Bernitz Furnace Appliance Co., located at 350 Madison Ave., New York City.

ANNOUNCEMENT is made that the Steel Tank & Products Corp., with offices at 4827 South Whipple St., Chicago, Ill., and plant at Aurora, Ill., has obtained that portion of the engineering staff and a coast to coast sales force which formerly designed and sold zeolite water softeners and pressure sand filters for the Paige & Jones Chemical Co. of Hammond, Indiana. M. H. Cleaver of New York, formerly district sales representative for the Paige & Jones Chemical Co., will be the district sales representative for the Eastern Division of the Steel Tank & Products Corp. O. E. Mitchell of Dallas, Texas, formerly district sales representative for the Paige & Jones Chemical Co., will be the district sales representative for the state of Texas, and John S. Paige, formerly chief engineer for the Paige & Jones Chemical Co., will be technical director for the Steel Tank & Products Corp.

R. H. PARK, for the past six years with the General Electric Co. in various engineering capacities, has recently joined the Stone & Webster Engineering Corp. at its Boston office as engineer in the electrical division.

BROOKLYN EDISON CO. has recently ordered thirty 2000-amp. subway type network units from the Westinghouse Electric and Manufacturing Co. at a total value of approximately $52,000. These protectors are to be used in the general expansion program of the company in adding to its present low voltage a. c. network system. The protectors will be mounted in submersible tanks that bolt directly to the side of network transformers which in turn serve as the mounting for the network protectors. The Madison Gas & Electric Co. has also ordered thirteen 1200-amp. network protectors from the Westinghouse company. Nine of these protectors are of the submersible type and the other four of the open type. This order has a value of approximately $18,000 and represents the largest order yet placed by the Madison Gas & Electric Co. for a. c. network protectors.

GENERAL MOTORS CORP., Detroit, Mich., has acquired the Winton Engine Co. of Cleveland, Ohio, builder of marine and industrial Diesel engines, it is reported. The latter company will be known as Winton Engine Corp.; officers and personnel of the old company will remain with the new organization, it is stated.

SARCO CO., INC., 183 Madison Ave., New York City, announces the following changes in sales representatives: F. W. Scheer, Andrews Bldg., Pearl and Court Sts., Buffalo, N. Y., for western New York State as far east as Syracuse, inclusive; the Erie section of Pennsylvania has been turned over to the Cleveland office, in charge of F. K. Minor, 805 Bulkley Bldg.; Williamson & Woody, 1138 Mutual Bldg., Richmond, Va., for the State of Virginia, except extreme north portion; Engineering Equipment Co., 209 Glenn Bldg., Atlanta, Ga., for the Georgia, excepting the coastal counties and the vicinity of Chattanooga, Tenn.; Stewart Roberts, 215 W. 7th St., Chattanooga, Tenn., for that territory.

C. C. FULLER has recently been appointed manager of the Foxboro Co.'s New York office. He replaces the late W. W. Patrick. He will have complete charge and will be assisted by K. L. Barton, R. A. Rockwell and F. J. Leerburger.

PAIGE AND JONES CHEMICAL CO. announces that it has sold to The Permutit Co. the Zeolite and Lime Soda Water Softening and Filter Departments of its business and that The Permutit Co. will furnish repair parts and replacements for Paige-Jones mechanical equipment now in use.

RECENT DEVELOPMENT of a Durolite steel dragline block with only 6-in. sheave diameter makes these blocks now available in a wide range of sizes from 6 to 42 in. They were first put on the market about 4 yr. ago in standard sizes of 12 to 30 in. Development of larger coal-storage and earth-moving power scraper machines, however, has caused the addition of blocks of 36 and 42 in. diameter to the standard sizes, and at the other end of the line small Durolites with 10, 8 and 6-in. sheaves have been developed for special purposes such as underground excavating where absolute minimum weight is the prime requirement. These blocks are a product of Sauerman Bros., Chicago, Ill.

WITH THE APPOINTMENT of L. B. Mead of Indianapolis to become assistant industrial manager of the Northwest District of the Westinghouse Electric & Mfg. Co., Wm. J. Morgan of Indianapolis becomes Indianapolis manager for the firm.

BIGELOW-LIPTAK CORP., Detroit, Mich., announces the appointment of Charles C. Plummer as manager of its sales office in Chicago. Mr. Plummer was formerly Chicago district manager for the R. H. Beaumont Co. of Philadelphia. The Bigelow-Liptak Corp. also announces the transfer of W. D. Dreiske, formerly in the Chicago office to the Detroit office as sales engineer.

T. V. WHITTIER, for the past 13 yr. with the Blackstone Valley Gas and Electric Co., first as chief engineer and later as superintendent of power, has joined the Stone & Webster Engineering Corp. as engineer in the power division. At present he is in Baton Rouge in connection with the operation of the Louisiana Station of Louisiana Steam Products, Inc. Mr. Whittier has been associated with the Stone & Webster organization for 23 yr., during which time he has worked for Tampa Electric Co., Houghton County Electric Co. and Blackstone Valley Gas and Electric Co.

IT IS ANNOUNCED that the Chicago District Electric Generating Corporation, recently organized, has succeeded the State Line Generating Co., with power plant near Hammond, Ind., and the company will be known under the first noted name in the future. The same ownership continues with identity with the Insull interests, Chicago, including the Commonwealth Edison Co., Public Service Co. of Northern Illinois, Northern Indiana Public Service Co., and other power organizations. Work is now under way on two additional units at the Hammond plant. The first noted to provide for a capacity of 132,000 kw., scheduled for completion in 1932, and the other of 125,000 kw. rating, to be ready for service in 1933. The present plant has an output of 208,000 kw., and was placed in operation during the summer of 1929. The Chicago District company has arranged for a bond issue of $15,000,000, a portion of the proceeds to be used for general financing in connection with plant construction and operations.

CUMBERLAND COUNTY POWER & LIGHT CO., Portland, Me., has secured approval of the State Public Utilities Commission, for the acquisition of the power properties and facilities of the Pepperell Mfg. Co., Biddeford, Me., including a number of water power sites still to be developed. The property will be purchased for a consideration of $2,300,000, and will provide for large increase in the facilities of the Cumberland company at the place noted. In the future, the purchasing company will furnish service for the operation of the textile mills of the Pepperell organization. Heretofore, the power properties have been operated by the Clark Power Co., a subsidiary of the selling company. The Cumberland company has also secured authority to issue bonds in gross amount of $2,400,000, to defray the purchase of the Biddeford holdings. It is understood that as soon as the properties are taken over, the Cumberland organization will carry out an expansion program in the district noted, including transmission line construction.

Books and Catalogs

HEAT ENGINES. By Charles N. Cross. Published by The Macmillan Co., 60 Fifth Ave., New York, N. Y.; 6 by 9 in., cloth, 592 pages; price, $5.00.

A well written and carefully arranged book, with a good balance between theory and practice and with sufficient history to make interesting reading. The first third of the book, comprising 11 chapters, is devoted to thermodynamic theory, heat and work, fundamental laws of gases, expansion and compression, vapors and engine cycles, while the balance of the book is devoted to what may be termed power plant practice; fuels and combustion, steam boilers, steam turbines, steam engines and internal combustion engines, the latter chapter being a 100-page book in itself. Not the least important feature is the inclusion of sufficient data on modern stations to give a cross-section of current power plant practice. This and many references to other books and current technical literature make the book of real value both to the student and engineer. In as far as thermodynamics, boilers, combustion and prime movers are concerned, it meets the needs of the power plant engineer as well as any single volume could possibly do, and fills a long felt need for a book of this type.

HI-LO CRANE, designed to provide maximum lift in minimum headroom, is completely described in a recent bulletin by Whiting Corp., Harvey, Ill.

'SAIRSET, an air-setting, high-heat resisting fire-brick bonding mortar, its composition, use in laying firebrick, in surfacing over in repair work and other applications is discussed in a recent 16-page well illustrated bulletin by A. P. Green Fire Brick Co., Mexico, Mo. In another 24-page illustrated bulletin, the company describes Quick-Pach, fire brick in plastic form. Methods of using it are shown for such work as one-piece furnace linings, repairs, door jambs, arches and the like.

RESEARCH FOR INDUSTRY, a 30-page illustrated bulletin, has been published for industrial executives and research directors by Battelle Memorial Institute, Columbus, Ohio, to describe the scope of its activities.

ANNITE, an all-purpose cleaning compound, is described in a recent 16-page bulletin by Quigley Co., Inc., 56 West 45th St., New York City.

MODERN CENTRAL STATIONS, Vol. 6, of a series of bulletins containing reprints of articles from the technical magazines, has just been published by Ingersoll-Rand Co., 11 Broadway, New York. These articles are mostly detailed descriptions of notable recent central stations and the present collection includes articles on Pasadena Municipal Plant, Riverbend, Ohio River, James H. Reed, Deepwater, South Amboy, Mobile plant of Southeastern Production Co., Gorgas No. 2, Rio Grande, Devils River. Two general articles are also included, one on central stations by George A. Orrok, the other by Harvey N. Davis and Joseph H. Keenan on Recent Research on the Thermal Properties of Steam. This volume is a valuable addition to a series of publications in which all utility engineers should be interested.

FLOW SHEET and Description of the continuous Meier coke retort for producing either low or high temperature coke with maximum recovery of byproducts is given in a recent bulletin by Meier Coke Retort Co., 1315 West Lockwood Ave., Kirkwood, Mo.

SPANNING THE UNIVERSE, a recent 40-page attractively-bound bulletin of the National Electric Light Association, 420 Lexington Ave., New York City, gives in English, German and French, a complete account of the international program between the N. E. L. A. convention and the World Power Conference, conducted on June 18, 1930, by telephone, radio and cable. Addresses of Lord Derby, Thomas A. Edison, Dr. Carl Koetgen and all the other speakers who participated are given in full.

THE MODERN Industrial Drive, a discussion of the synchronous motor, its principles, construction and applications are given in Bulletin L-5, a recent 16-page well illustrated publication of Elliott Co., Pittsburgh, Pa. Power factor, flywheel effect, damper windings and other subjects are treated. Bulletin J-2 describes the Elliott Compensated machine, a type of direct current generator and motor, explaining the principles of compensation by diagrams and oscillograms and the construction features of the equipment. Bulletin J-3 describes engine-type alternating current generators, discussing efficiency, voltage regulation, Diesel and gas engine applications. Bulletin Z-8 describes and illustrates the Liberty Tube Cleaners of the Liberty Mfg. Co., Jeannette, Pa. Special uses in oil refineries, special large and small cleaners, surface cleaners, Jiffy gun for shooting condenser tube plugs are discussed.

AMERICAN AIR FILTERS for Compressors, Diesel Engines and Gas Engines are illustrated and described in Bulletin 120 by American Air Filter Co., First and Central Ave., Louisville, Ky.

COLLINS WESTERN WATER TUBE BOILERS of the curved tube type, designed to give rapid circulation with large water capacity and high overload capacity are illustrated and described in a new bulletin by Collins Western Corp., Ltd., 517 Hollingsworth Bldg., Los Angeles, Calif.

RECORDING INSTRUMENTS, alternating and direct current are described in Bulletin GEA-122A by General Electric Co., Schenectady, N. Y. In Bulletin GEA-546A, Carrier-Current Telephony as applied to high-voltage transmission lines is discussed. Elementary explanation is given of the principles of the single-frequency duplex system, with details of the parts and their operation.

WEBSTER BOILER PROTECTOR for protecting low-pressure heating boilers against low water is described and illustrated in a catalog issued by Warren Webster & Co., Camden, N. J. Details of construction and installation are given. Range for steam pressure is up to 15 lb. and for supply water pressure up to 150 lb.

NICKEL STEEL Alloy Forgings, their uses, manufacture and properties are discussed in Bulletin No. 17 issued by the International Nickel Co., Inc., 67 Wall St., New York, N. Y. Also in Bulletin No. 1-A of the same company are given the standard specifications for steels of the Society of Automotive Engineers, covering carbon steels, screw stock, steel castings, nickel, nickel-chromium, chromium, chromium-vanadium, molybdenum, tungsten and silico-manganese steels. Points covered are chemical properties, inspection, tests, finish of castings and marking of castings.

NEW EIGHT-PAGE circular No. 1892, published by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., describes Metal Enclosed Truck-Type Switchgear, manually and electrically operated, built for three-phase, 60-cycle supply, 3000 amp. maximum and 15,000 v. maximum. In this equipment, all high-voltage circuits are enclosed to assure safety for the attendant. This circular is well illustrated with photographs and diagrams of the equipment and presents a thorough discussion of its application and construction. Table of interrupting capacities and dimensions is given.

TWO-STAGE AIR COMPRESSORS, straight line tandem type are described in Bulletin 153 just published by Pennsylvania Pump & Compressor Co., Easton, Pa. Details of construction are described and illustrated. Data are given on a new type of compressor, Class 14-A and 15-A, either power or steam driven, in which the low-pressure cylinder is double-acting and the high-pressure cylinder is single-acting.

BOILERS, SUPERHEATERS AND ECONOMIZERS are discussed in the latest report No. 081, of the Prime Movers Committee, National Electric Light Association, 420 Lexington Ave., New York. Steam generator installations in 1929, says the report, show a marked increase in boiler capacity, with one plant using a boiler which has produced 1,250,000 lb. of steam an hour.

Steam pressures and temperatures have increased. More than 15 boilers are operating at 1400 lb. or over and the steam temperature in a large number of stations is 750 deg., while a few stations expect to use 775 and 800 deg.

Embrittlement is still a problem but knowledge of its control has been greatly extended and methods for its absolute prevention seem to be available.

Use of water-cooled furnace walls, particularly on the larger units, is almost standard practice. In some instances, as much as 65 per cent of the heat liberated in the furnace is absorbed in the water walls.

Methods of welding have progressed so that some engineers prophesy the acceptance of welding for pressure parts of steam generating units in the near future.

WILLIAMS SOCKET WRENCHES for all types of industrial service are described in a new 10-page illustrated bulletin by J. H. Williams & Co., Buffalo, N. Y.

IN THE REPORT No. 078 on Turbines, just issued by Prime Movers Committee, National Electric Light Association, 420 Lexington Ave., New York, operating records are given for 276 turbines during 1929. Results of tests on 20 turbines, ranging from 3500 kw. to 94,000 kw., are also presented. The report also contains statements by operating companies on recently installed, large capacity units and unusual operating conditions.

ROWLAND FORGE WELDED CONTAINERS for shipment of liquefied petroleum gases and forge welded storage tanks for gases and liquids under pressure are described in bulletins 2002 and 3003 just issued by American Welding Co., 30 Church St., New York.

BIBLIOGRAPHY OF HYDROELECTRIC SUBJECTS and manufacturers statements is the title of Publication 086 just issued by the Hydraulic Power Committee, National Electric Light Associa-

tion, 420 Lexington Ave., New York. This report is the annual bibliography of important articles relating to hydroelectric plants and practice, appearing in various technical periodicals, engineering society transactions and the like during 1929, also the annual review of important progress in this field as seen by the hydraulic turbine manufacturers. It is essentially a record of progress. It is interesting, the report states, to observe the note of optimism resulting from renewed activity in the hydroelectric field consequent on a more complete realization of the possibilities of properly designed hydroelectric plants for peak load service and the generation of base load energy when conditions are proper for it.

DESCRIPTION of the new Nicholson industrial steam trap, a large capacity bellows trap for pressures from 0 to 100 lb., is given in Bulletin 830 by W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

ENGINEERING DATA on Foxboro V-port controlled valves are given in an attractively illustrated 36-page bulletin, No. 167, by The Foxboro Co., Foxboro, Mass. Principles of controlled valve reactions are discussed, curves and data are given on flow characteristics, pressure drop and so on, computations of valve size are shown. V-port valves are described in detail and their applications illustrated. Tables and charts give capacities, sizes and other data for use of designers.

BACHARACH ENGINE INDICATORS, Maihak type, are described in Bulletin 262 just issued by Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa. Detailed description is given of the indicators and their accessories, with tables of data for selecting them to fit conditions.

BRISTOL'S AIR-OPERATED CONTROL EQUIPMENT is described in a well-illustrated 24-page catalog, No. 4000, just issued by The Bristol Co., Waterbury, Conn. This gives detailed description of the equipment and all its parts, shows how it is applied and includes a price list.

ROTARY COMPRESSORS and Dry Vacuum Pumps are illustrated and described by Yeomans Bros. Co. 1433 Dayton St., in a new Bulletin, A C-7100. These compressors are designed for all pressures up to 50 lb. gage. Details of the units are given, with tables of sizes and ratings.

ELECTRICALLY-DRIVEN AUXILIARIES for Steam Generating Stations, Publication No. 088, is a report of the Electric Apparatus Committee, National Electric Light Association, 420 Lexington Ave., New York. Construction of several large new generating stations together with the recent developments in methods of driving station auxiliaries, has made desirable a revision of the 1924 report on this subject. This report summarizes the requirements of electric drive in recent years and compares them with the requirements indicated in the earlier report. Types of auxiliary drive and methods of supplying power are summarized for 37 new stations or additions to old stations in which a definite change in plan was undertaken.

METHODS WHICH are used by employers to provide safe working conditions in their plants are described in a report entitled Making the Plant Safe. This publication, which has just been issued by the Policyholders Service Bureau of the Metropolitan Life Insurance Co., is the ninth in a series of reports based upon a study of the field of safety engineering and designed to present the principles governing successful accident prevention work. The current study discusses the need for adequately guarding certain types of machinery and certain operations, and relates some of the fundamentals for instituting these safeguards and getting them used. Other sections of the study deal with the maintenance of guards, the machinery which should be protected, plant housekeeping and the proper care of hand tools as a matter of accident prevention. Copies of Making the Plant Safe, as well as other publications in the Industrial Safety series, may be secured by addressing the Policyholders Service Bureau at One Madison Ave., New York City.

THE STOCKHOLM EXHIBITION of 1897 was supplied with power and light from four combined boiler, turbine and generator sets designed for a working pressure of 2850 lbs. per sq. in., while the log of operation shows actual pressures as high as 3420 lb. per sq. in., and temperatures up to 750 deg. F. This early work of Dr. De Laval, famous as the inventor of the centrifugal milk and cream separator, is described in a pamphlet entitled A Pioneer in High Pressure Steam, now being distributed by the De Laval Steam Turbine Co., Trenton, N. J. Other novel and original features of the Stockholm Exhibition were a flash type boiler, automatic control of combustion, independent control of primary air beneath the grate and secondary air above the fuel bed, cooling of the furnace walls and air preheating.

A NEW CATALOG featuring Brown indicating, recording and automatic control pyrometers has just been issued by The Brown Instrument Co., Philadelphia, Pa. This catalog contains 104 pages with 141 illustrations, many of which are in two or more colors. A comprehensive resume of the theory and practice of applied pyrometry is presented, together with descriptions and illustrations of all instruments, thermocouples, protecting tubes and other required equipment.

NEW BOOKLET describes the patented, self-contained leather oil seal manufactured by the Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill., and lists the dimensions of the stock sizes made for use with shafts from ½ in. to 12 in. diameter.

UNION CHAIN & MFG. CO., Sandusky, O., has just issued a new 124-page catalog on Silent and Roller Chain of its manufacture. The catalog contains complete data on these types of chain, also engineering data to aid chain users in figuring chain drives. It also contains engineering data on sprockets used in conjunction with silent and roller chain drives and on chain attachments for special purposes.

BOOK NO. 78 on Stock Chain Drives has just been published by the Diamond Chain & Mfg. Co., Indianapolis, Ind. These drives, intended for the majority of motor and countershaft applications, are available from ¼ to 75 hp., in ratios up to 8.4 to 1, in motor speeds up to 1800 r.p.m. Complete tables, full instructions are given in the catalog together with many interesting applications.

Pumps, Turbines, Compressors and Speed Reducers for the oil industry are illustrated and described in a 40-page publication distributed by the De Laval Steam Turbine Co., Trenton, N. J. The publication also contains chapters on the characteristics of centrifugal pumps when handling oil and other viscous liquids, on different hydraulic systems of balancing centrifugal pumps, on the effects of skin friction of impellers, and on the influence of the number of stages upon efficiency. Various constants, formulas and tables of use to engineers and others concerned with oil refinery and pipe line problems are included.

STEAM GENERATION STEPS AHEAD. By G. B. Gould; 102 pages, 5 by 7½ in.; price, $1.00. Published by Fuel Engineering Co. of New York.

Taking up principally the fuel problems encountered in industrial steam plants in sizes ranging from 500 to 5000 hp., the author addresses his study of plant operation to the executives of industrial plants. The nontechnical character of the treatment is maintained throughout the book and the principles laid down for economical steam generation are illustrated by numerous examples taken from the author's experience as a fuel engineer. Chapter headings are as follows: Advancing Standards in Steam Generation, the Relation of Plant Design and Operation to the Coal Market, the Importance of Separately Appraising Plant Performance and Coal Values, Coal Characteristics which may Modify Plant Performance, Predicting Coal Quality Commercial Opportunities for Profit and Loss in Coal Buying, Controlling the Major Variables in the Cost of Steam, the Structure of the Coal Market, and Economic and Engineering Trends in Steam Generation. Throughout the entire book, the author points to the practical methods of controlling steam generation and the interpretation of information gathered from records into terms of practical business significance which is of extreme importance to the executive.

CENTRIFIX COMPRESSED AIR CLEANER, Type RD, designed for installation in air piping to remove dirt, oil, moisture and other impurities from the compressed air, is the subject of Bulletin 158 issued by Centrifix Corp., 3029 Prospect Ave., Cleveland, Ohio.

BURKE Clamp Type Positive Grip Tee Connectors are discussed in Bulletin C.T.4 and Controlead Terminal Blocks in Bulletin H-2 recently published by Burke Electric Co., Erie, Pa.

AUTOMATIC AND PARTIAL AUTOMATIC HYDROELECTRIC PLANTS, just issued as Publication No. 083 by Hydraulic Power Committee, National Electric Light Association, 420 Lexington Ave., New York City, discusses briefly the salient features of such plants and tabulates the principal characteristics of 104 plants of this type.

Mechanical Reliability of Hydroelectric Units—1928, Publication No. 084 of the Hydraulic Power Committee, presents outage records of 191 units classified as to type of turbine and cause of outage for the year 1928.

A third bulletin, Publication No. 082, of the same committee treats of Ice Problems in Hydroelectric Plants. It describes methods of insulating and degree of heat used to maintain sluice gates in operation in winter, methods of keeping open channels in front of flashboards, electrically heated rack bars, open channel methods for diverting slush ice and methods of insulating and heating surge tanks. Tabulations show the energy consumed and principal dimensions of the various structures on which data were obtained.

Power Plant Construction News

Ark., Pine Bluff—The Arkansas Power & Light Co., Pine Bluff, is considering the construction of a high-tension transmission line from its hydroelectric power plant at Carpenter to power substation at Pine Bluff, reported to cost over $80,000. Company engineering department is in charge. A power substation will be constructed at Montrose, Ark., to cost about $30,000.

Calif., San Francisco—The Merchants Ice & Cold Storage Co., Battery and Lombard Streets, has made application for permission to dispose of a stock issue approximating $2,500,000, a portion of the proceeds to be used for general expansion and improvements.

Calif., Salinas—The American Rubber Producers, Inc., Matson Building, San Francisco, affiliated with the Inter-Continental Rubber Co., plans installation of electric power equipment in proposed local mill, for which work will proceed at once, entire project to cost about $130,000. A boiler house will be built.

Colo., Longmont—The Common Council is said to be considering an addition to the municipal electric light and power plant for auxiliary service. Estimates of cost will soon be made.

Fla., Jacksonville—The Florida Fruit Packing Corporation, care of C. H. Murchison, Barnett Building, recently organized, plans installation of electric power equipment in proposed fruit packing plant, entire project reported to cost close to $75,000.

Fla., Tampa—Tom Huston, Columbus, Ga., operating a local food product plant, plans installation of electric power equipment in proposed new citrus food canning plant at Tampa, entire project to cost about $100,000.

Ill., Lockport—The Northern Illinois Cereal Co., Lockport, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported in excess of $100,000.

Ind., South Bend—The Bendix Aviation Co., South Bend, plans installation of electric power equipment in proposed aircraft apparatus manufacturing plant, entire project reported to cost more than $100,000.

Iowa, Independence—The City Council is said to be planning the purchase of Diesel engine units for municipal power service.

La., Colfax—The City Council is considering the installation of a municipal electric light and power plant for which estimates of cost will soon be made.

Mass., South Weymouth—The Weymouth Light & Power Co., Weymouth, has plans in progress for a new one-story power substation at South Weymouth, reported to cost about $35,000, with equipment. E. J. Batty, 13 Temple Street, Quincy, Mass., is architect.

Mass., Waltham—The Board of Public Works plans the installation of pumping machinery and auxiliary equipment, in connection with extensions and improvements in municipal waterworks for high pressure service. Project will also include a standpipe.

Mich., Detroit—The Detroit Edison Co., Detroit, has begun the construction of a new equipment storage and distributing plant at Sylvan Lake Village, reported to cost more than $75,000.

Mich., Detroit—The Great Lakes Steel Corporation, subsidiary of the National Steel Corporation, plans installation of electric power equipment in proposed new plant addition, entire project reported to cost over $350,000.

Mo., Kansas City—The City Ice Co., has approved plans for extensions and improvements in ice-manufacturing plant at Twenty-first and Campbell Streets, including installation of additional equipment.

Mo., Sikeston—The Common Council is arranging for the early construction of a municipal electric light and power plant, for which bonds in amount of $150,000, were recently authorized. The W. A. Fuller Engineering Co., 2916 Shenandoah Avenue, St. Louis, is engineer.

N. J., Perth Amboy—The Board of City Commissioners is considering extensions and improvements in municipal electric light and power plant, including installation of new equipment. Estimates of cost will soon be made. Dr. John V. Smith, commissioner of Public Works.

N. Y., Hadley—The Niagara Hudson Power Corporation, Buffalo, N. Y., is said to be planning the construction of a hydroelectric generating plant on the Hudson River, near Hadley, to cost more than $1,000,000, with transmission system.

N. Y., New York—The New York Central Railroad Co., 466 Lexington Avenue, has filed plans for a one-story power substation on 134th Street, reported to cost about $40,000.

Ohio, Cincinnati—The R. A. Becker Varnish Co., Cincinnati, plans installation of electric power equipment in proposed one-story two-unit plant on the Laydon Farm Road, reported to cost over $85,000. Rendigs, Panzer & Martin, Southern Ohio Bank Building, are architects.

Ohio, Lima—The Superior Body Works has filed plans for extensions and improvements in steam power house, including installation of boilers and auxiliary equipment.

Ohio, Marietta—The City Council is reported to be planning the installation of a municipal electric light and power plant to cost close to $100,000.

Okla., Hobart—The City Council is said to be planning the installation of power and pumping machinery in connection with extensions and improvements in municipal waterworks to cost close to $400,000. A bond issue will be arranged. The Benham Engineering Co., Perrine Building, Oklahoma City, Okla., is consulting engineer.

Okla., Hominy—The Common Council has tentative plans under way for a municipal electric light and power plant, reported to cost about $50,000, with equipment.

Okla., Vinita—The City Council has plans maturing for a municipal electric light and power plant to cost about $200,000. Russell & Axon, McDanel Building, Springfield, Mo., are engineers.

Pa., Homestead—The Mester Machine Co., plans installation of electric power equipment, in connection with a new addition to rolling mill machinery manufacturing plant, entire project reported to cost more than $100,000.

Pa., Philadelphia—The Board of Directors, Philadelphia Country Club, has filed plans for a one-story boiler plant to cost about $21,000, with equipment.

Pa., Pittsburgh—The Jones & Laughlin Steel Corporation will install electric power equipment in connection with an expansion and improvement program, now under way, entire project reported to cost more than $6,000,000.

S. C., Barnwell—The Coast Public Service Co., Barnwell, is said to be considering the rebuilding of portion of local ice-manufacturing plant, recently destroyed by fire. An official estimate of loss has not been announced.

Tenn., Coal Creek—The Southern Coal & Coke Co., Knoxville, Tenn., plans installation of electric power equipment, in connection with extensions and improvements at coal mining properties, including new tipple, entire project to cost about $135,000.

Tenn., McKenzie—The City Council has authorized plans for extensions and improvements in municipal electric light and power plant, including installation of additional equipment. V. V. Long & Co., Colcord Building, Oklahoma City, Okla., are consulting engineers.

Texas, Thomaston—The Central Power & Light Co., San Antonio, is considering the construction of a new hydroelectric generating plant on the Quadalupe River, near Thomaston, reported to cost more than $1,000,000. Application for permission has been made.

Wash., Bellingham—The Pacific Coast Paper Mills, Inc., Bellingham, plans installation of electric power equipment, in connection with an expansion and improvement program, reported to cost more than $300,000.

W. Va., Huntington—The West Virginia Rail Co., Huntington, plans installation of electric power equipment in connection with a new addition to plant, entire project to cost over $200,000.

Wis., Grafton—The Board of Village Trustees, plans the installation of pumping machinery in connection with a municipal waterworks and sewage system, entire project to cost close to $70,000. Paul L. Clark, 207 West College Avenue, Appleton, Wis., is consulting engineer.